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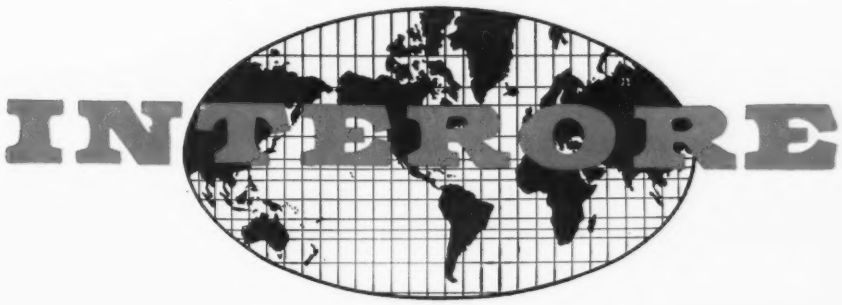

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Review

Duisburger Kupferhütte, the largest pyrites residues treatment plant in the world, forms an integral part of Germany's sulphuric acid industry and also holds the key to Europe's pyrites industry. Close on two million tons pyrite residues are currently converted in the extensive chemo-metallurgical installations, which fronting on the River Rhine, have the benefit of cheap transport on the network of waterways in North-West Europe for raw materials and end-products. The latter include one million tons iron as pig iron and purple ore, 19,000 tons copper in the form of metal and salts, 33,500 tons zinc as oxide and metal, 800 tons cobalt, 130,000 tons Glauber salt, 27 Kgs. gold, 47 tons silver, 50 tons cadmium, 10 tons thallium. The relatively high fuel and power requirements are the main cost item, but skill and ingenuity backed by over 80 years experience are constantly improving the economics of operation. The close co-operation between pyrites producers, pyrites consumers and Duisburger Kupferhütte indicates the measure of importance which attaches to the realisation of the metal values in pyrites to keep the cost of sulphur in pyrites competitive with brimstone and other forms of sulphur.

The Sulphur Industry of New Zealand is almost exclusively represented by the manufacturers of sulphuric acid and superphosphates. As the result of a major expansion programme of the industry initiated in 1954, the number of sulphuric acid/fertilizer plants has risen from eight to fourteen and these provide annually 300,000 tons sulphuric acid and one million tons superphosphates. Sulphur consumption is exclusively in the form of brimstone which is at present imported from the U.S.A. and Mexico. The development and efficiency of New Zealand's pastoral industry is largely determined by its intensive use of fertilizer. Despite setbacks in the marketing of its products, New Zealand agriculture is expected to expand its use of fertilizer and in consequence of sulphur, thus enhancing the importance of this already sizeable brimstone market.

In the **United States** production of Frasch and recovered sulphur during the first quarter of 1958 amounted to 1,460,000 tons, 3¾% less than in the preceding quarter and 5½% less than in the first quarter of 1957, the decline being entirely due to lower Frasch sulphur production. Apparent sales of Frasch and recovered sulphur totalling 1,254,000 tons were 8½% lower than in the same period of 1957 and despite the deliberate reduction in production caused stocks to rise by 205,000 tons to 4.8 million tons at the end of March. Imports from Mexico, consumed in Florida and on the Atlantic seaboard, rose to approximately 138,000 tons, an increase of 27% compared with the first quarter of 1957. Despite current difficulties, which are reflected in lower earnings, U.S. Frasch sulphur producers view the future of their industry with confidence. The start of construction by the Freeport Sulphur Company of the Grand Isle plant, the industry's most ambitious project to date, raises the number of new domes to three. At the same time Jefferson Lake and Texas Gulf Sulphur Companies are extending their interests into Canada's rapidly expanding recovered sulphur industry.

The current annual rate of one million tons sulphur exports from **Mexico** is 25% higher than that in 1957. Production of Mexican Frasch sulphur originates from the domes of the Pan American Sulphur Company, Gulf Sulphur Corporation and Texas Gulf Sulphur Company whilst exports are entirely sustained by the two first named companies. Most of Mexico's rising domestic requirements are met by recovered sulphur produced by Pemex who are increasing their recovery facilities and in the form of native sulphur ore from Los Cerritos. Pan American production is currently exceeding an annual rate of 800,000 tons practically all of which is filtered. Gulf

Sulphur reports that technical difficulties have been successfully overcome and average production during March was 700 tons per day which is expected to rise shortly to 900 tons per day. Texas Gulf Sulphur continued to stockpile its entire output of 7,000-8,000 tons per month. During the quarter the entire assets of Mexican Gulf Sulphur were bought by the Mexican Government who, so far, have not announced any plans for their utilisation.

Consumption of sulphur in the **United Kingdom** at 243,000 tons during the first quarter showed a decline of 1½% compared with the coresponding period of 1957, mainly as the result of the lower level of industrial activity. Sulphuric acid demand, except in the growth industries of titantium and detergents, declined by about 2% to 615,324 tons. Of particular interest was the fall in acid consumption for the manufacture of superphosphate and ammonium sulphate which may be indicative of new trend in the fertilizer industry. Diffiiculties in the rayon industry were primarily responsible for the continued decline in non-acid sulphur consumption. The relatively high rate of sulphuric acid production kept many pyrites plants in operation thus accounting for the high level of pyrites usage, but as new brimstone plants under construction or projected come into operation during 1958 and 1959 the pronounced trend in the United Kingdom towards brimstone and away from pyrites will be continued.

Increased sulphuric acid demand in **India** during the current five-year plan is expected to result in great requirements of brimstone. This might be partly met by indigenous sources of recovered sulphur which could supply 17% of India's anticipated requirements by 1960. Development of sulphuric acid installations to suit India's specific requirements, such as that of D.C.M. of Calcutta, are likely to play an important part.

Elemental sulphur production in Japan in 1957 totalled 258,000 tons. Although only 4% lower, a drastic drop in demand mainly as the result of reduced viscose rayon activity has changed the picture from shortage and to one of over supply. High production costs, competition from domestic recovered sulphur and the threat of abundant and cheap world supplies create a difficult situation for Japan's sulphur producers whose strength, however, rests on their intimate co-operation with a large section of consuming industries and on the Government ban on sulphur imports.

World prices of brimstone have steadied in the past three months partly as the result of a slight easing of competitive pressure. Significantly the downward trend of world commodity prices has also been arrested. The re-establishment of the Sulphur Export Corporation enables the U.S. Frasch sulphur industry to show a united front in her overseas markets where later this year Mexican competition is likely to harden. Whilst anxious not to depress the world price level of sulphur and to base prices on those of United States and Mexican supplies, Société Nationale des Pétroles d' Aquitaine have the competitive advantage of lower freights to most major markets and this must be expected to come into play as the need arises. The price of European pyrites has been further reduced by up to 8%, as from 1st July. Their competitive position position is improved and in some instances, notably in Germany, superior to brimstone despite lower residues values.

World supplies of brimstone continue to mount. Production capacity of Frasch, recovered and native sulphur is rising, the net additions in the past six months being estimated at 440,000 tons per annum. World stocks are at present estimated to total 6.0 million tons. In Europe the reduced level of pyrites sales this year leaves much mine capacity unused. In the United States and Canada lesser by-product pyrites output, as the result of reduced non-ferrous metal ore operations, provides some redress for reduced consumption.

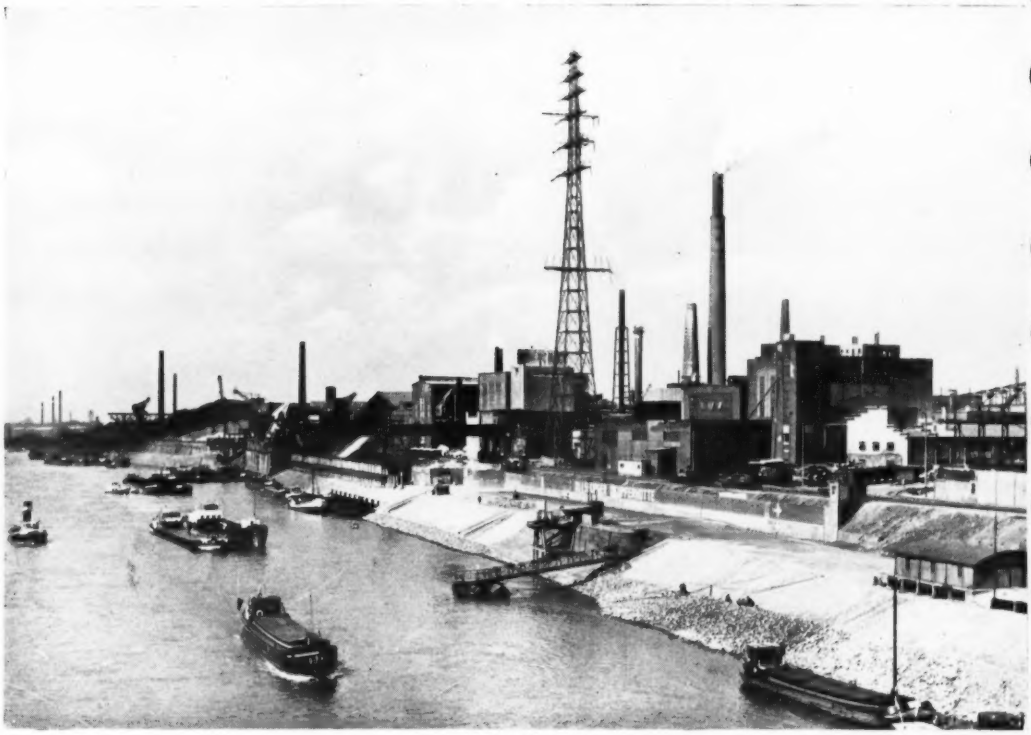
Duisburger Kupferhütte

HOLDING the key to pyrites usage in Western Europe is the great complex of metallurgical and chemical plants which exist for the sole purpose of extracting and recovering as economically as possible the useful constituents of the metallic residues which remain after the sulphur content of pyrites has been burnt to SO_2 for subsequent conversion to sulphuric acid. Fundamentally Duisburger Kupferhütte performs to-day the same task as it did 82 years ago when the company was founded by ten prominent German acid makers with the object of reducing the cost of pyritic sulphur. Then, as now, Duisburger Kupferhütte bulk purchases pyrites on behalf of a large sector of the German sulphuric acid industry and the selection of the sources of pyrites supply continues to be influenced largely by the metallurgical needs of the plant. Originally—as the name indicates —copper was the works' principal product and pyrites yielding residues with 2-4% copper were the main raw materials. The declining copper content of pyrites supplies, apparent since the 1920's has entailed significant process changes which are manifested in the more intensive extraction of metals and chemicals to make up for the generally lower grade of the pyrite residues. Despite the apparent changes, Spanish pyrites continue to form the basis of raw materials supply and processing steps are much influenced by their composition, but quantitatively their importance has diminished commensurately with the increased usage of pyrites originating from other European suppliers.

The works are situated on the East bank of the Rhine, in the inland port of Duisburg and near the mouths of the River Ruhr and Rhine-Elbe canal. The link by river and canals —which extend all over North-West Europe— with major ports, where pyrites arrive by seagoing vessels, and with most sulphuric acid plants permits the full use of water transport. Especially the Rhine barges of 1,000-2,000 tons carrying capacity, provide very low-cost movement of pyrites residues from acid makers in Germany and neighbouring countries, and practically all the raw materials used in the treatment of residues—such as coke, salt, lime, coal—also arrive at the works by the cheap water route. Of the end-products, purple ore, but also copper and pig iron, are generally despatched by water to the customers of Duisburger Kupferhütte at home and abroad. Elaborate discharge and bulk handling facilities of the raw material arrivals direct into specific sections of the plant, the movement of intermediate products between the individual sections of the plant, and finally the disposal of end-products, play a major part in sustaining the economics of operation.

Duisburger Kupferhütte is the largest and most elaborate cinders treatment plant in the world. Other major plants in operation are Kupferhütte Ertel, Bieber and Company, Hamburg, Metallhüttenwerk Lübeck A.G., Lübeck-Herrenwyk, Montecatini at Porto Marghera in Italy, Reymersholm Gamla at Helsingborg and Oskarshamn in Sweden, Witkowitz in Czechoslovakia and since April, 1958 Compania Uniao Fabril at Barreiro, Portugal, but at these plants activities are as a rule based only on the extraction of copper and the supply of iron as purple ore, sinter, or pig iron. There are also a few copper leaching installations—the survivors of an important and widespread feature in the pyrites industry before World War II — and some specially adapted sintering plants, such as the Stürzelberg plant of S.A. Cros' associates Siderurgia Industrial Cia Iberica S.A. in Barcelona and that of Sachtleben A.G. at Homberg/Niederrhein, which treats exclusively zinciferous Meggen residues preparatory to lithopone manufacture. Outside Europe the only major installation is that of Pyrite Company Inc., at Wilmington, Delaware, where, however, following the cessation of Spanish pyrites exports to the United States, the character of operation has much changed.

To-day, throughput capacity at Duisburger Kupferhütte is about 1.9 million tons residues, more than double the 1938 throughput of 875,000 tons. The works suffered grievous war damage, but post-war reconstruction fostered by British occupation authorities under pressure primarily from the British-owned Spanish pyrites producers, rapidly re-instated this essential adjunct not only of the German sulphuric acid



General view of Duisburger Kupferhütte fronting on River Rhine.

and chemical industry, but of European pyrites. Physical reconstruction was accompanied by the establishment of new ownership in proportion of the capital structure. The share capital is now D.M. 42 million (£3.6 million) and is held jointly and in equal (30.17% each) parts by Farbwerke Hoechst A.G., Badische Anilin & Soda Fabriken and Farbenfabriken Bayer, Germany's principal chemical and metals interest, and the balance by Gebr. Giulini GmbH. (4.40%), Chemische Werke Albert (2.40%), Chemische Fabrik Curtius GmbH. (1.50%), and E. Matthes & Weber GmbH. (1.18%).

Residues Supply

Satisfactory extraction and processing entails the prior careful blending of the wide range of the residues which Duisburger Kupferhütte obtains from its principal associated German pyrites roasters—which include Badische Anilin & Soda Fabriken, Farbwerke Hoechst, Farbenfabriken Bayer, Chemische Werke Albert—and also from individual plants and from groups of sulphuric acid makers abroad. These residues are derived from pyrites originating from Spain, Portugal, Norway, Cyprus, Finland, Turkey, Canada, Cuba and Germany, and their physical and chemical properties vary considerably. The range of their metallic constituents is shewn below, but in addition, pyrites residues contain some 50 other elements, the extraction and recovery of which, in view of the very small quantities involved is not, however, economic.

	Per Cent		*Grammes per ton*
Iron	42 -60	Cobalt	50 -6,000
Gangue (Silicic acid, Alumina, Lime)	3 -17	Nickel	10 -1,500
		Manganese	300 -3,000
Sulphur	1.5 - 6	Silver	5 - 80
Copper	0.1 - 4	Gold	0.1- 2
Zinc	0.5 -11	Cadmium	30 - 200
Lead	0.02- 1.2	Thallium	5 - 100

An important factor in the satisfactory treatment of pyrites residues is arsenic. If present in any quantity, it adversely affects the chemical processes whereby the non-ferrous metal ores extracted, but most important—its presence in purple ore, sinter or pig iron very

significantly detracts from the value of these products, which after all, represent the mainstay of the operation. Despite the presence of arsenic in most pyrites, especially Spanish and Portuguese, roasting at medium temperatures and progressively in hearth furnaces volatilises most of it so that the residues are practically free from arsenic. Roasting of arsenical pyrites in a fluidised bed has created a problem, in that the arsenic—mainly due to high temperature combustion and speed of roasting—remains locked in the residue. In view of the increasing application of this roasting method a solution is urgently being sought, but despite several of palliative remedies, such as heat recovery at multi-hearth roasters or two-stage fluid bed roasting, the problem awaits solution.

Processing of Pyrites Residues

In Figure 1 the sequence of process steps which are later described in detail are indicated. A notable feature is their interrelation and the use of ancillary products; the use of "washing tower" acid resulting from the chloridising roaster for copper leaching is an instance of this, but of greater importance, is the use and re-use of steam and blast furnace gas which helps to meet the works' heavy energy requirements. These, it is estimated, amount to the equivalent of one ton of coal for every ton of pyrite residue treated up to the pig-iron-stage.

The fundamental treatment stage is chloridising roasting, which, as the Longmaid-Henderson-Process, was first used in England about 100 years ago and whereby copper was converted to a soluble chloride or sulphate by the use of common salt. Here at the Duisburger Kupferhütte 100 parts of pyrites-cinders are mixed with approximately 8-10 parts of common salt, and this mixture is ground to about 6mm. particle size, after which this so-called ground ore is heated to 550-600°C (1,022-1,112°F) in special roasting furnaces. The roasting with the addition of common salt breaks down the pyrites-cinders permitting the separation of all the compounds soluble in water and in dilute acid from the remaining

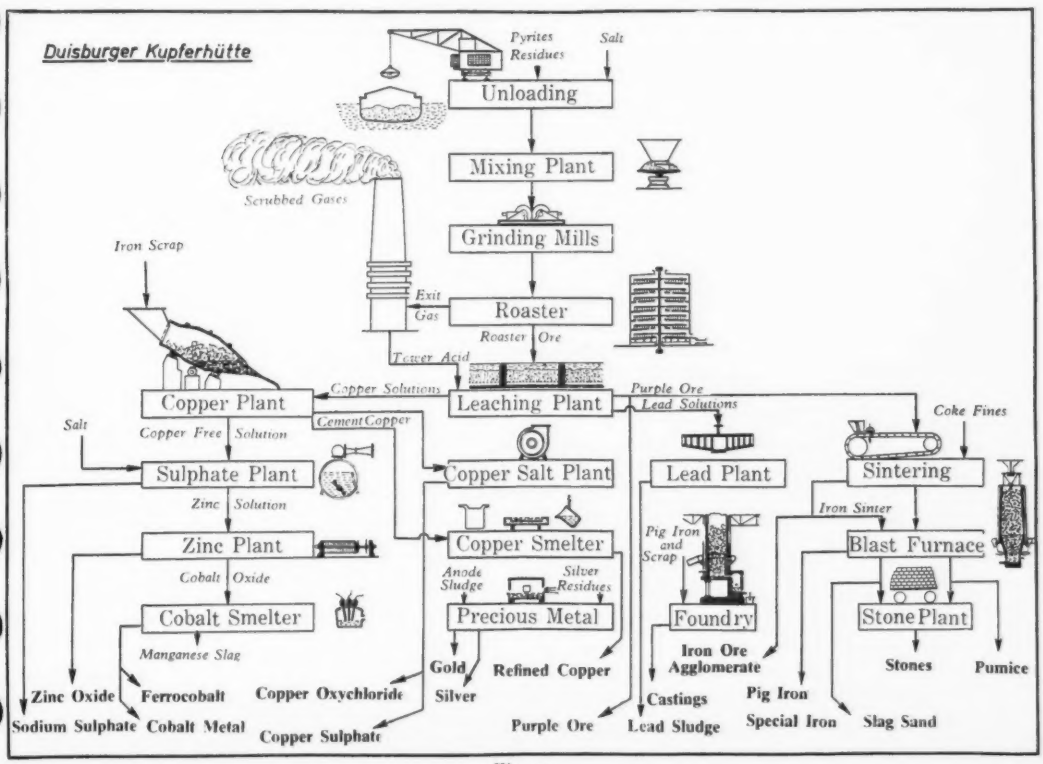


Fig. 1.

iron ore. The iron ore, also known as purple ore on account of its colour, contains only fractional amounts of non-ferrous metals and sulphur formerly contained in the pyrites-cinders. These are collected in the acid salt solution or "lye" which is treated to obtain the metals and salts. The cinder mixtures, which are prepared by collecting pre-determined quantities of residues from the intermediate dumping grounds where each grade has been delivered by belt conveyor from the Rhine barge, have approximately the following range of composition:—

	Per Cent		*Grammes per ton*
Iron	54 -58		
Gangue (Silicic acid, Alumina, Lime) ...	6 -10	Cobalt ...	300 -1,500
		Silver ...	25 - 50
		Gold ...	0.5- 1.5
Copper	0.8- 1.5	Cadmium	40 - 100
Zinc	2 - 3.5	Thallium	15 - 45
Sulphur ...	2.5- 4		
Lead	0.3- 0.7		

Roasting is effected in 36 multi-hearth furnaces, similar to those used for pyrites roasting, but whereas the latter process is

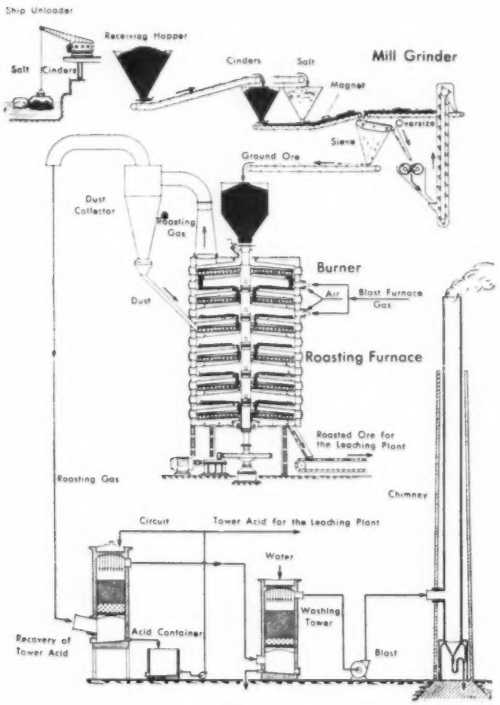


Fig. 2.

strongly exothermic this, despite the residual amount of combustible sulphur, requires a heavy heat input in the form of blast furnace gas. The exit gases containing SO_2, SO_3 and HCl are washed and the resultant "washing tower acid"—corresponding to 7% HCl—is as previously mentioned, used in the leaching plant.

The roasted ore at 400°C (752°F) on leaving the furnaces is conveyed to the pre-leaching section of the leaching plant, where it is wetted and cooled on large rotating tables to promote uniform leaching. In the big leaching tanks of 150 to 300 tons capacity the extraction is carried out on the principle of the percolating leach in which the lixiviant fed into the full tank slowly percolates through the warm roasted ore and leaves the tank through a filter bottom of acid-proof stones and layers of gravel. The treatment period extends for about two days. For the purpose of extracting gold, chlorine water has to be fed into the tanks subsequent to copper leaching, and this dissolves a small part of the amount of gold present.

Copper Precipitation

To reduce the amount of iron passing into the solution the conventional precipitation process of copper on to scrap iron has been modified. Instead of scrap iron, copper sludge drawn from the end of the precipitation line is added to the leach solution in the first three of the thirteen large—12,000 gallons—precipitation drums. The bluish-green bivalent copper salts are being converted by the copper sludge into colourless monovalent copper salts, although the solution is turned pink by the cobalt compounds present. The monovalent copper salts are for the most part precipitated in the form of cupreous chloride on account of their partial solubility, and are separated by a suction filter. The remainder of the copper salt in the solution is recovered with the aid of a small amount of scrap iron in the form of cement copper, and this also contains most of the silver and gold present in the residues. The solution from which the copper has been extracted, flows to a settling basin from which it is pumped to the sodium sulphate plant.

Copper Recovery

(a) *Cupreous Chloride:* This is dissolved in a hot solution of sodium chloride and the resultant solution pumped into another tank with atmospheric oxygen being admitted to yield copper oxychloride which has a copper content of almost 60 per cent. Considerable

amounts of this copper oxychloride were formerly used in the manufacture of artificial silk. To-day the artificial silk factories are in a position to recover the copper salts from their own solutions via ion exchangers. However, considerable amounts of copper oxychloride are still being used as fungicides on vines, fruit, vegetables and potatoes.

(b) *Smelting:* At first dried cement copper is pelletised on a rotating table. In the copper smelting plant these pellets are sintered and then smelted in large reverberatory furnaces fired with blast furnace gas and gas or oil. The furnace charge amounts to about 80 tons of copper. The refined copper is cast into anode plates weighing 350lb. each, ready for electrolytic refining which is effected at the works of the Norddeutsche Affinerie situated in Hamburg. Electrolysis also yields the precious metals in a black anode sludge which is worked up into a gold-bearing refined silver by means of the cupelling process. The refined silver is further treated by way of precious metal electrolysis to produce needle-shaped and extremely pure electrolytic silver. This is remelted and subsequently marketed in the shape of granulated silver. Like copper electrolysis, silver electrolysis produces a black anode sludge which contains the gold, and after further refining is cast into gold anodes. The gold anodes are subjected to another electrolysis which produces in addition to extremely pure electrolytic gold, small amounts of metals belonging to the platinum group. The latter were present in the cinders in less than an one-hundred millionth part.

Sodium Sulphate

The copper-free solution coming from the copper precipitation plant contains larger amounts of sodium sulphate and sodium chloride as well as valuable salts of zinc, cobalt, cadmium and thallium. Prior to the metals being recovered the sodium sulphate is crystallized out, mostly in the form of Glauber salt. For this purpose the solution is cooled from 40-50°C (104-122°F) to 0°C (32°F) by a partial vaporization of the solution in vacuum. The necessary vacuum is provided by means of steam jets which are operated on a principle similar to that of water jet pumps as used in laboratories. The cooling is done in twelve successive stages. The amount of energy needed is supplied by the exhaust steam from the turbine of the power station.

The Glauber salt, which has been crystallized out, is separated from the remaining zinc solution in large centrifuges which are automatically controlled. To reduce the high --56%--content of water of crystallization the salt is melted in its own water of crystallization and by repeated centrifuging at temperatures above that of the conversion point at 32°C (90°F) an anhydrous sodium sulphate is produced. In the first stage the mother liquor

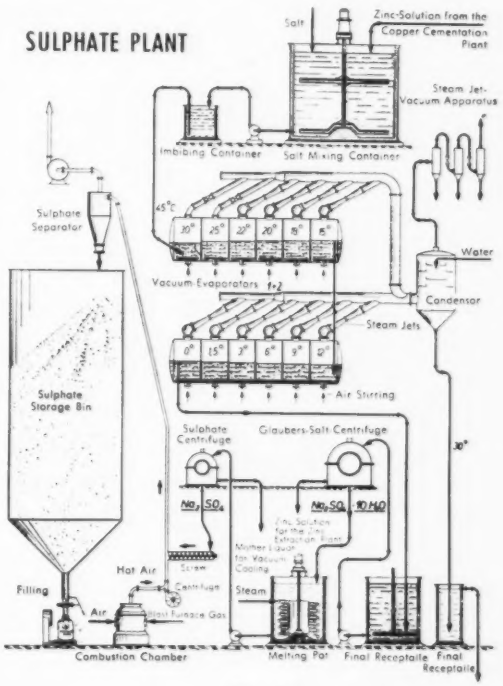


Fig. 3

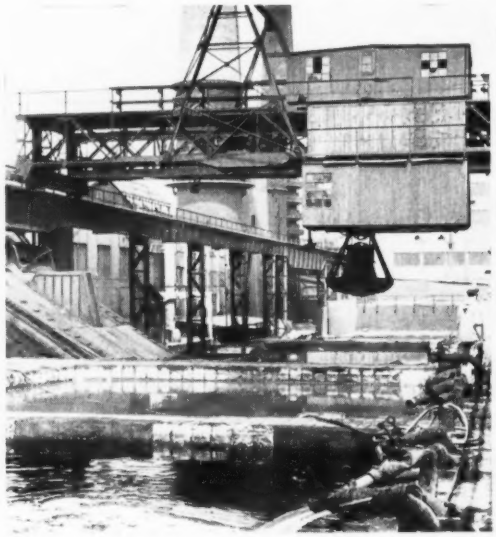
obtained during the conversion process is returned to the vacuum cooling section. In the second stage it is worked up into a sodium sulphate of outstanding purity.

Extraction of Zinc and other metals

The object of the final stage of the treatment of the lye is to recover the zinc and the rarer metals: cobalt, cadmium and thallium and salts of manganese and nickel. To recover these metals, the solution is first freed from the iron compounds which were formed from the scrap used in the copper precipitation plant. The bivalent iron salts in the solution are

oxidised to trivalent iron compounds partly by oxidising with air and partly by using elemental chlorine, and they are precipitated at a certain pH-value by means of lime. The small amounts of sulphate not precipitated in the process of extracting the Glauber salt are simultaneously precipitated in the form of gypsum. The gypsum-iron sludge is allowed to settle in thickeners; it is then filtered and washed by means of rotary filters. Cobalt is next recovered, and to avoid contaminating the cobalt sludge with nickel, the solution is oxidised with chlorine gas and cobalt precipitated with zinc hydroxide. The first cobalt precipitation which contains impurities in the form of salts of manganese and zinc as well as smaller amounts of salts of iron and copper, is not suited for immediate processing into a high-grade cobalt metal. It is only after further precipitation that an enriched cobalt hydroxide is obtained in the shape of a green sludge which contains a mixed oxide of cobalt and manganese after being subjected to heat treatment in a calcining drum. The further working up of this mixed oxide into cobalt metal is carried out in the smelting plant.

Subsequent to the precipitation of cobalt, the trace metals cadmium and thallium, as well as smaller amounts of indium, are recovered from the lye by means of zinc dust cementation. These metals are obtained in the form of a dark-coloured cementation product, which is worked up by a new process of the amalgam chemistry into 99.95% cadmium metal, into thallium in metal form, or in sulphate form and into indium metal. It is only after these delicate processes that the obstacles to precipitating the large amounts of zinc can be said to have been removed. Here, too, lime as the cheapest technical alkali, is used to obtain the zinc in zinc hydroxide form. The precipitate is concentrated and washed in large thickeners subsequently filtered by means of rotary filters and finally dried and clinkered in rotary kiln furnaces at temperatures of up to 1,350° C (2,450° F). A zinc oxide with approximately 70% zinc content, which represents a valuable starting material for metal production, is produced. The originally white precipitate is coloured green by the small amounts of nickel. Part of the zinc solution is subjected to a special purifying process and the zinc is precipitated by means of pure soda. In this way it is possible to produce a very pure zinc oxide of some importance to the glass, enamel, ceramic and chemical industries. This year an electro-thermal zinc plant has been installed which permits the manufacture of refined zinc from agglomerated zinc oxide. Small quantities of nickel are also recovered.



Leaching Plant.

Lead

The extraction of lead from the leach solution at 85% Pb cement lead is believed to have proved too costly in relation to the value of lead and the ratio of recovery. The present lead operations at Duisburger Kupferhütte are therefore confined to working up lead flue dust collected from sulphuric acid plants and, as indicated above, to collecting the residual silver-bearing lead in the purple ore or sinter at the base of the blast furnaces in the form of pig lead. The low lead price makes even this only marginally attractive, and special research into this aspect of recovery is in progress.

Iron

The removal of practically all non-ferrous impurities leaves in the leaching tanks a very pure high-grade iron ore which has an iron content of 61-63% and is practically free from phosphorus. About two-thirds of this purple ore is sold to neighbouring blast furnace plants, while roughly one-third is worked up into

pig iron at Duisburger Kupferhütte's furnaces. Ten per cent coke fines are added and the ore is converted to lump-size iron ore sinter or agglomerate on the continuous sintering belts of a Dwight-Lloyd sintering plant. The red-hot sinter is cooled on a cooling conveyor by means of air to a temperature that permits its uninterrupted transport on rubber belt conveyors to the blast furnace. From the iron ore sinter the four blast furnaces at the Duisburger Kupferhütte produce forty special grades of pig iron. They also supply—as a valuable by-product—blast furnace gas which as indicated above is used for heating the roasting furnaces, the drying drums, the copper melting furnaces and the air heaters. The slag, a by-product of blast furnaces, is also utilised in the form of slag sand, which is supplied to cement works.

A special feature of the blast furnaces of the Duisburger Kupferhütte is a lead tapping, whereby silver-bearing lead is added drop by drop. The lead does not alloy with the pig iron and at the high temperature in the blast furnace it is sufficiently free flowing to percolate through the carbon bricks of the hearth. To assist its flow gas jets are used at special discharge apertures.

A foundry, in conjunction with the blast furnace plant, produces acid-resistant castings to supply the firm's own demand and that of the chemical industry. The foundry is equipped with hot-blast cupola furnaces.

ECONOMIC ASPECTS

An important feature of processing the large volume of residues, from which many metals present only in small amounts have to be recovered, is the very elaborate control system involving weighing, sampling and assaying, not only at the intake of residues into the plant but also at each processing step to ensure the fullest possible utilisation of the constituents. In this respect it is of interest that in the determination of weight by gauging of the incoming barge cargoes of residues the degree of accuracy is within 0.1%, which exceeds that of chemical and moisture determination.

The economics of extraction of the non-ferrous constituents of residues are governed by the percentage of recovery and the value of the end product set against the processing costs.

Since the metal content of residues varies appreciably whilst the composition of purple ore and sinter are stable, it is not practicable to specify percentages of recovery for individual metals. The following guaranteed maximum metal contents, when compared with the metal content of residues, provide a measure:—

	Purple Ore Max. %	*Agglomerate Max. %*
Copper	0.10	0.10
Zinc	0.2-0.3	0.15-0.20
Lead	0.4-0.5	0.3 -0.3
Silver	0.06	0.03
Sulphur	0.4-0.5	0.1 -0.12
Phosphorus	0.01	0.01
Residue	8-9	8.9
Iron	60-62	61.5-63

The materials balance of Duisburger Kupferhütte is indicated as follows:—

Current Annual Input :

1.8-1.9 million tons pyrites residues :
180,000 tons salt
90,000 tons coal for power station
20,000 tons iron scrap
150,000,000 KWH
300,000 tons blast furnace coke

Yield

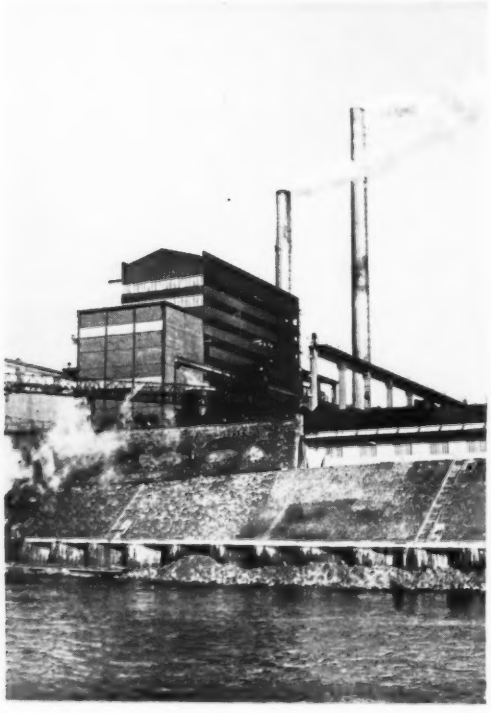
Copper (copper oxychloride & Anode Copper)	19,000 tons
Zinc (zinc oxide & Refined zinc)	33,500 tons
Purple ore (with about 20% moisture)	1.9 million tons
Iron content	450,000 tons
Gold	27 kgs.
Silver	47 tons
Cobalt	800 tons
Cadmium	50 tons
Thallium	10 tons
Glauber Salts	130,000 tons

The value of these end products determines the price which Duisburger Kupferhütte can establish for the various grades of residues. A major factor, however, is the cost of transformation; the skill and experience of management and staff is reflected by the improvements in metal recovery and greater economy of fuel and materials resources in processing which are constantly being achieved. It is estimated that of the total costs power and fuel represent 60%, labour 25%, overheads 10%, materials 5%, so improvements in technology, rather than increased throughput appear to make the main impact on reduction of costs. In 1957, whilst throughput rose 7½% to 1.866 million tons residues and turnover increased 5% to DM. 336.6 million, net profit declined DM. 10.3 million to DM. 2.6 million. Shareholders received a dividend of 7%—payable on the full capital of DM. 42 million since 1st July, 1957—and employees, as in previous years, shared in the profits.

The German pyrites roasters associated with Duisburger Kupferhütte and for whom

Duisburger Kupferhütte bulk purchase pyrites, account for about 90% of total German consumption of imported pyrites. Their pyrites supplies are priced on the basis of "sulphur only," Duisburger Kupferhütte retaining the title to the residues, and in so doing carrying the commercial risk of the valuation of residues.

In the matter of requisitions and valuation of residues from outside Germany, which account for one-quarter to one-third of total residues intake, close collaboration exists between Duisburger Kupferhütte, the pyrites producers who have co-ordinated their interests in the Pyrites Residues Organisation and the pyrites roasters. The principle of co-operation was initiated about ten years ago, when pyrites producers, notably Rio Tinto, instead of reverting to the pre-war system of selling



New Roasting and Leaching plant. Built in 1955-57, it has an annual throughput capacity of 430,000 tons residues.

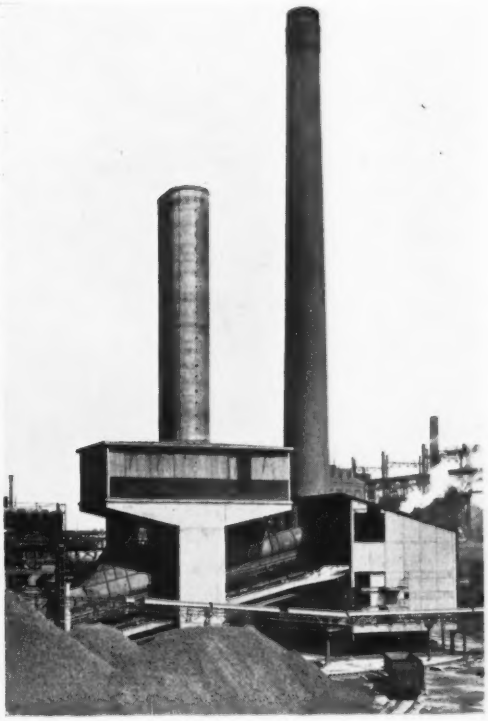
sulphur values only and retaining the title to the residues decided, whilst still supporting the end user of pyrites, to place the onus of cinders disposal firmly on his shoulders. To-day, despite some setbacks and differences of interests, it can be said that the object of avoiding unduly adverse or unfavourable conditions which, arising out of circumstances outside the control of the industry might affect only one of the parties, has been achieved. All purchases by Duisburger Kupferhütte are effected by their exclusive purchasing agents, Cie Belgo-Continentale, of Brussels, and Vereenigde Ertshandels Maatschappij N.V., of the Hague. Periodical price reviews, controlled buying and acceptance of responsibilities beyond those limited to ordinary business risks have created conditions of close inter-dependence.

Conclusion

In Western Europe, pyrites consumption is, if not absolutely declining, certainly declining in relative importance. Cheap United States and Mexican Frasch sulphur and recovered brimstone are making inroads into many established pyrites markets. In most instances of new plant installation the amortisation factor leaves the acid maker little choice but to abandon pyrites. In Germany generally, and at specific plants favoured by special circumstances in other countries, it can still be claimed with justification that sulphur in pyrites is cheaper, but only because roasters have realised peak prices for residues whilst the "all-values" cost of pyrites has declined.

The high residues values and the firm market of recent years are attributable almost exclusively to the demands of Germany's blast furnaces which in 1957 consumed 10.4% of the iron intake of 18.1 million tons in the form of pyrites residues as such (3.9%) or as purple ore obtained in their treatment (6.8%). The former originate from pyrites which are sufficiently free from non-ferrous metals to meet the stringent requirements of iron masters who dislike their presence, especially of copper. Montecatini residues are an outstanding example of almost pure iron ore being derived from pyrites and Cyprus Mines flotation concentrates are also notable for their favourable composition. As the result of marketing conditions during the past two to three years, the earlier pressure of excessive quantities of residues in the hands of foreign roasters has progressively been replaced by Germany seeking to purchase cinders stocks abroad, with the result that several millions of tons of Spanish, Portuguese and North African "non-

cupreous " residues were taken into consumption. Simultaneously, the traditional influence of iron ore prices on residues values had if anything, become more pronounced. The concurrent changes in world sulphur markets highlighted the vital part which Duisburger



Sinterbelt cooling plant. Completed in 1956.

Kupferhütte plays in European pyrites affairs and its essential balancing function mitigating the impact of relatively high pyrites prices by being able to attach a commensurately high value to the residues.

Recent events in the heavy industries of Germany and other West European countries, and further expansion in the potential world brimstone supply, have naturally affected Duisburger Kupferhütte; despite the massive backing which the German sulphuric acid industry may be expected to give, Duisburger Kupferhütte is no longer sanguine that its capacity and that of other European cinders extraction plants will continue to be effectively used. There is about three million tons treatment capacity for cupreous—in the wider sense—residues, that is those containing 0.7% copper or more. For non-cupreous residues, which can be used direct by blast furnaces, the only measure of the outlet is the availability of sintering facilities coupled with individual blast furnace practice and/or prices.

The present slower rate of iron ore consumption and the heavy stocks in Germany and neighbouring countries, coupled with low sea freights, has seriously depressed this market with inevitable repercussions on purple ore and pig iron values which Duisburger Kupferhütte might realise. As yet the outstanding success of Duisburger Kupferhütte's negotiations earlier this year secures European pyrites roasters good returns for this year's deliveries of pyrites residues. There is, however, little doubt, if the difficulties experienced by roasters now trying to sell residues direct to blast furnaces are taken as a guide, that a serious reappraisal of values is being forced on Duisburger Kupferhütte, mitigated only by a slight reduction of its fuel bill.

Thus the pyrites producers' predicament is evident. The situation is not made any simpler by the possibility that under a combination of adverse conditions pyrites as at present priced may lose markets at a more rapid rate. Pyrites producers are examining the possibilities and the implications to their revenue of treating by flotation, crude ores with higher non-ferrous metal contents, to obtain at the mines metal concentrates and cheap by-product pyrites; possibly even more attractive would be the realisation of low-grade mines stocks for up-grading to a cheap sulphur concentrate, the residue of which would serve as straight sintering charge. It is evident that such developments on a major scale would wholly change the character of the European pyrite industry and seriously affect Duisburger Kupferhütte. In the meantime, Duisburger Kupferhütte must be expected to exert its strong influence to ensure a level of traditional European pyrites use commensurate with her intended utilisation of available residues treatment capacity. The versatility and superb equipment of the plant would lend itself to a variety of chemo-metallurgical processes, but as Dr. Ing. Schackmann, the managing director, said recently—" the sole aim and object of Duisburger Kupferhütte is to process pyrites residues as efficiently and cheaply as possible."

We are indebted to Messrs. Duisburger Kupferhütte for information and illustrations placed at our disposal.

NEW ZEALAND

A CONSIDERABLE expansion in the sulphuric acid industry has taken place during the last five years and has established New Zealand as one of the world's prominent importers of sulphur. This expansion has resulted from the fertilizer demands of the agricultural industry upon which New Zealand's economy is based. Rapidly expanding post-war development and the introduction of new farming methods, such as the fertilizing of hill country from the air, have led to a greatly increased demand for fertilizer and this, coupled with high rail freight charges and other distribution problems, called for the construction of new fertilizer plants.

Current consumption of sulphur, exclusively in the form of imported brimstone, is of the order of 100,000 tons a year, of which less than 5% is used for industrial purposes. The balance is converted to sulphuric acid, production of which is estimated to be 300,000 tons a year.

Superphosphates

The fertilizer industry is almost entirely concerned with the production of superphosphate. About 870,000 tons were produced in 1957, accounting for nearly all the sulphuric acid made in New Zealand.

In 1953, there were eight plants producing superphosphate. Since then, four new plants have been built or are nearing completion, while two existing plants have been considerably enlarged. Producers of superphosphate now fall roughly into two categories, the older established fertilizer companies, and new companies including those formed by local groups of farmers which, incidentally, have a claim to substantial funds held by the Meat, Wool and Dairy Boards.

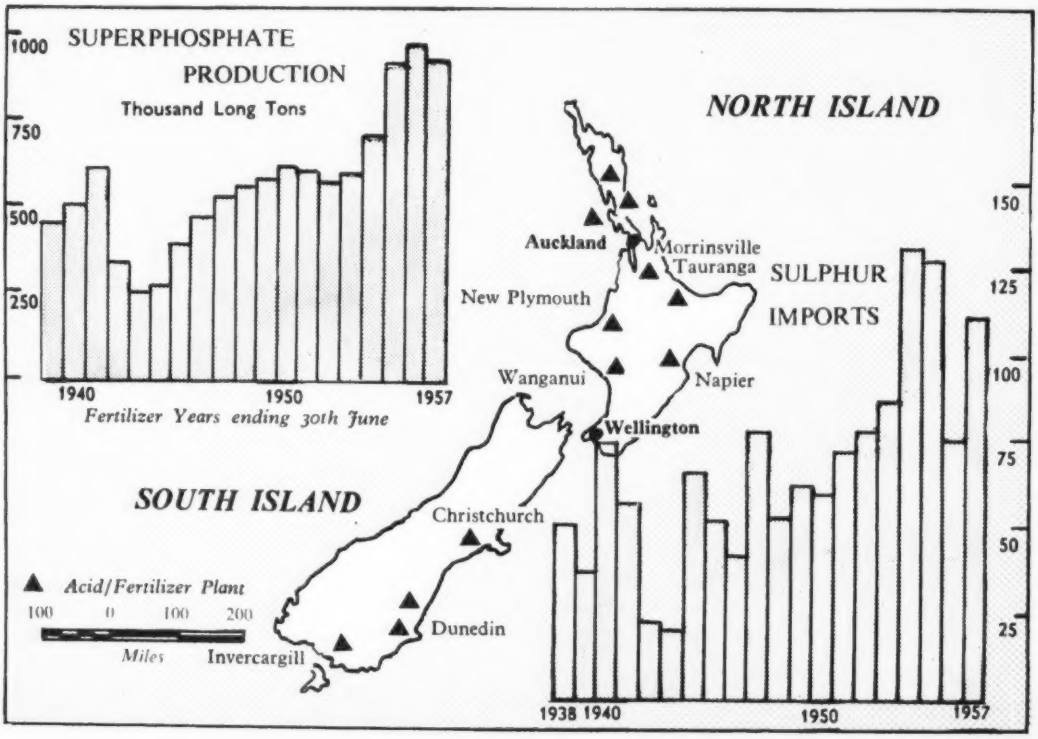


Fig. 4.

Kempthorne Prosser and Company are the oldest established firm engaged in the production of superphosphate. In 1881, they were able to claim a bonus of £500 offered by the New Zealand Government to any firm or individual who would manufacture 50 tons of sulphuric acid in a year. Their Burnside Works near Dunedin, established in that year, were rebuilt in 1929 and can now produce 60,000 tons of superphosphate a year. In 1887 they built a works at Westfield, near Auckland, while their plants at Hornby, near Christchurch, and Aramoho, near Wanganui, were

Kempthorne Prosser. General view of Hornby Works.

established in 1922 and 1927 respectively. *New Zealand Farmers Fertilizers Limited*, established works at Te Papapa, near Auckland, in 1921, and at New Plymouth in 1926. These plants can produce 100,000 and 200,000 tons superphosphate a year respectively.

The plant built in 1921 by the *Challenge Phosphate Company Limited* at Otahuhu, near Auckland, now has a capacity of 200,000 tons a year. The last of the older works is that of the *Dominion Fertilizer Company Limited* who built their plant at Ravensbourne, near Dunedin, in 1929.

The current phase of expansion in the sulphuric acid and superphosphate industry began in 1954 when the *East Coast Farmers Fertilizer Company Limited* built a plant at Napier to produce 100,000 tons of superphosphate a year. This capacity was doubled when an additional acid plant built by Simon-Carves Limited came into operation in 1957.

To meet the growing demand for fertilizer from the rapidly expanding farming districts of South Auckland, the *Kiwi Fertilizer Company* was formed by the New Zealand Farmers Fertilizer Company and the Challenge Phosphate Company. The need for a new works in this area had been accentuated by a transport "bottleneck" created by the huge demands made on road and rail traffic, through which essential supplies of fertilizer could only be squeezed with difficulty. Shortly after World War II it became clear that steps would have to be taken to overcome these difficulties. Plans for a new fertilizer works were delayed by the world sulphur shortage, but when this was overcome, extensive surveys were carried out to find the best possible site. After careful investigation a site was chosen near Morrinsville and construction was started by the Kiwi Company who placed a contract for the sulphuric acid plant with Simon-Carves Limited. The works are due for completion in October this year and will have a superphosphate capacity of 120,000 tons a year.

As a challenge to the Morrinsville Works, a new company, the *Bay of Plenty Fertilizer Works Limited*, has been formed to establish a new superphosphate works at Tauranga. The works, which are being built by the British firms of W. J. Frazer Limited of Romford and Simon-Carves Limited, have a superphosphate capacity of 120,000 tons a year and received their first cargo of sulphur in March.

Another new plant is that being built by W. J. Frazer Limited and Simon-Carves Limited for the *Southland Co-operative Phosphate Company*. The works, which will have a capacity of 120,000 tons superphosphate a year, are being built in collaboration with Frazer's New Zealand Agents, Cory-Wright & Salmon Limited of Wellington, and Downer & Company, also of Wellington, whom Frazers have appointed as civil engineering contractors, while Simon-Carves Limited are responsible for the sulphuric acid plant.

Expansion in the superphosphate industry has not been confined to new companies, for Kempthorne Prosser completed an additional acid plant at their Aramoho works in 1956, raising capacity there to 120,000 tons of superphosphate a year. While extensions to their works at Hornby completed last year have raised their superphosphate capacity to 130,000 tons a year.

Sulphuric Acid Production

Production, which is to-day of the order of 300,000 tons per annum, is very closely geared to the manufacture of superphosphate, acid plants being situated at all the superphosphate works. Construction of new sulphuric acid plants during the last four years have resulted in a change from the predominant use of the chamber process to that of the contact process.

It is of interest to note that all the new plants—at Napier and similarly at Otahuhu, Morrinsville, Awarua and Tauranga — are contact acid installations of Simon-Carves/Monsanto design with a rated capacity of 110 tons (100% H_2SO_4) per day. In these plants the burner gases are cooled to the correct temperature for catalytic oxidation of SO_2 to SO_3, the SO_3 being then absorbed in strong sulphuric acid. The ore used in molten sulphur combustion is pre-dried to prevent the formation of acid mist from the combination of water vapour with SO_3 gas. The plants in New Zealand are fitted with hot gas filters for purification of gas when leaving the chamber.

Since 1939 the number of sulphuric acid plants has increased from eight to fourteen, and production of sulphuric acid has doubled in this period. Estimated production in this period has been as follows :—

			CHAMBER PROCESS		CONTACT PROCESS	
*Year**	*No. of plants*	*Total production*	*No. of plants*	*% of total production*	*No. of plants*	*% of total production*
1939	8	153,183	8	100	Nil	Nil
1947	8	183,397	8	100	Nil	Nil
1950	8	213,585	8	100	Nil	Nil
1955	9	313,170	8	95	1	5
1956	9	330,096	8	91	1	9
1957	10	301,071	8	85	2	15
1958 (estimate)	11	301,000	8	75	3	25
1959 (estimate)	14	331,000	8	58	6	42

* Year ending 30th June.

Sulphur Supply

The British Phosphate Commissioners, who are responsible for supplying the phosphate used in New Zealand's superphosphate production from the deposits which they operate on Nauru, Ocean and Christmas Island, are also responsible for sulphur purchasing. The Commission sells sulphur to all superphosphate producers, at the same price, irrespective of the position of their works, so that producers with works situated well inland are at no disadvantage to those with works on the coast. Brimstone imported from the United States, and recently from Mexico, accounts for virtually all the sulphur used in New Zealand. Imports were raised considerably to the level of 125,000 tons per year in 1954 and 1955 to build up stocks after the recent sulphur shortage. Since then sulphur imports have been 74,860 tons in 1956 and 111,337 tons in 1957 and stocks have been reduced in view of the present abundant world supplies.

During the sulphur shortage attention was turned to the possibility of using Australian pyrites, but there is no likelihood of these supplies being used while cheap Frasch sulphur and brimstone are available from the United States and Mexico.

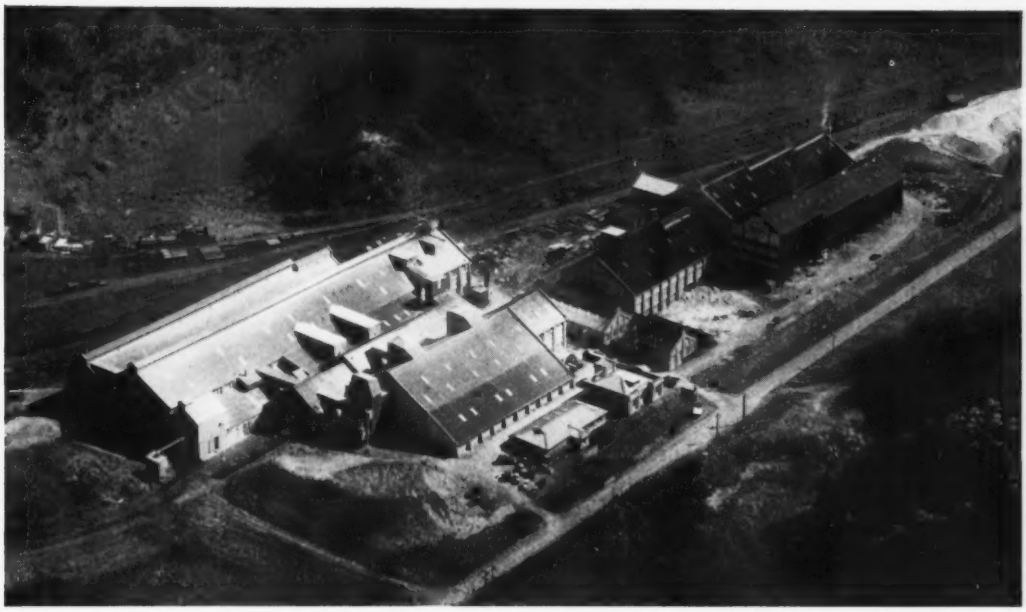
A low grade sulphide ore body has been discovered near Thames, North Island. Sampling has shown the presence of up to 20 million tons of rock above stream level, but the sulphur content is no higher than seven or eight per cent. It is unlikely that the capital needed to develop this will be provided, while a cheap and economic alternative supply is readily available in the form of imported material.

Fused Calcium Magnesium Phosphate

Experiments have been made in New Zealand in the use of fused calcium magnesium phosphate as an alternative to superphosphate. It has been found most effective in acid and neutral soils and less effective in alkaline soil. Although favoured by some sections of the farming community, it is doubtful whether it will ever have any marked effect on the production of superphosphate.

Aerial Application of Fertilizer

An important feature of New Zealand farming is the fertilizing of pastoral land. Much of this is now done from the air and the last eight years have seen the rapid development of this method of application which now absorbs more than one-third of the available fertilizer and is considerably increasing pastoral production on much of the second class hill land.



Kempthorne Prosser. General view of Aramoho Works

Year	*Weight distributed tons*	*Area treated acres*
1950	5,003	48,741
1952	88,869	802,212
1954	203,110	1,929,499
1956	404,933	3,853,169
1957	428,245	3,945,586
1958 (estimate)	430,000	4,000,000

New aircraft specially designed for aerial application and capable of carrying a ton of fertilizer on each flight are an important feature in the rapid expansion of this practice.

It now appears to have stabilised at the present annual level of distribution of just under half a million tons of fertilizer. With the next stage of agricultural expansion it may be expected that this successful and well-established method of application will grow commensurately, further stimulating the demand for fertilizer.

Conclusion

The use of fertilizer has played an important part in the growth of the agricultural industry of New Zealand, now one of the principal food producing countries in the world, and there is no doubt it is making a major contribution towards her still increasing prosperity. Whether or not the difficulties which New Zealand has recently encountered in world food markets will quickly be overcome, it is unlikely that the New Zealand farmers will economise on fertilizer consumption. They can be expected to take a long-term view and to maintain their demand for superphosphate which has served them so well, resulting in increasing consumption of sulphur. In so important a market there will continue to be strong competition between United States and Mexican Frasch sulphur producers, and before long these established sources will be challenged by recovered sulphur from Canada.

Prices and Trends

Brimstone

During the past three months the downward trend of world prices of brimstone has been virtually arrested and the strong pressure on prices, which competition had previously exerted, eased partly because the major proportion of this year's demand has now been covered by contracts. It is, however, significant that this change of emphasis in the sulphur price picture coincided with the halt in the fall of comodity prices in general. On examination of the Economist Index of seventeen basic commodities it appears that after a fall of 15% during 1957 and the first quarter 1958 to 84 (1952=100 and Korean War peak 141) the index in the second quarter not only steadied but even showed a 1% advance. In the same period sulphur prices compared on an f.o.b basis, declined by about 11% and landed prices due to the heavy drop in sea freights from the post-Suez peak by about 30%. At the present low ocean freights sulphur consumers throughout the world have been able to secure their requirements at a cheap c. and f. cost which has further been reflected in the reduced prices for indigenous recovered sulphur supplies. Despite this, halting trading conditions in many of the major sulphur-using industries and the existence of ample world sulphur supplies and producers' stock removed any incentive from consumers to expand their requisitions or stocks.

In the United States Frasch sulphur prices remain uniformly based on $25 per ton f.o.b. U.S. Gulf port or $23.50 per ton f.o.r. mine cars, for bright sulphur destined to home and export markets. Off-colour sulphur attracts a discount of $1 per ton. A slight improvement in the rate of deliveries has helped to steady prices, especially along the Eastern Seaboard, but Mexican imports continue to benefit from lower ocean freight rates than those charged by tariff bound vessels carrying U.S. supplies. To counteract this freight contributions are made resulting in some distortion of U.S. price. Prices of recovered sulphur have been widely adjusted to the lower levels now prevailing and the practice of special prices within limited localities is growing. A general tendency to criticise the low level of prices appears to have ceased, possibly because it further unsettled some major users and under prevailing market conditions was difficult to substantiate. The establishment of the sulphur Export Corporation‡, which now embraces the overseas interests of all United States Frasch sulphur producers may be said to have had a steadying effect on the price of United States sulphur abroad.

Quotations for Mexican Frasch sulphur continue to range from about $21.50 to $24 per ton f.o.b. Coatzacoalcos. The lower price range applies in particular to unfiltered supplies whilst on new contracts for filtered material it is the producers' aim to secure the top price. Favourable shipping opportunities appear to have improved the price attraction of Mexican sulphur sold from stockpiles at Tampa and on the Atlantic Seaboard.

Italian sulphur exports are further contracting as available export and production subsidies which have been bringing the gap between the notional export price of Lire 23,000 per metric ton (£13 7s. per ton) for Buona Sicilia (min. 98%S) and competitive supplies of Mexican and United States Frasch and French recovered sulphur are likely to be withdrawn when current contracts are completed. In any case in Mediterranean markets this gap is estimated at least Lire 5,000 (about £3 per ton). Available subsidy payments are expected to be applied to support the use of ore for sulphuric acid manufacture.

Refined sulphur from China is offered in shipload and larger quantities through merchants in the United Kingdom, Western Europe and Australia. The price of the material which contains guaranteed 99.5%S, 0.005% As, 6-8 ppm. selenium, progressively declined from the former level of £12 and now appears to be only about £10 f.o.b. Tientsin. Whereas of little interest west of Suez, it is marginally attractive to sulphur users in the East and particularly to Australia where offers are reported to be under serious consideration.

The domestic price of sulphur in Japan has been reduced in February by Yen 800 to Yen 21.200*. The reduction was made despite the steadily rising production costs and must be considered a gesture to consumers, especially in the viscose rayon industry, who are hard hit by the recession in their trade and who are conscious of the appreciably lower level of world sulphur prices.

‡ See Page 42

(* Yen 1,009=£1)

In Western Europe there have been no significant changes in the domestic prices of recovered sulphur despite the arrival of several low cost shipments of Mexican and United States Frasch sulphur, which benefitted from exceptional freight rates. Notable examples are deliveries by Freeport Sulphur Company to the company's stockpile at Hamburg, which supplies the German and Scandinavian markets; also a shipment of about 18,000 tons is reported to be on sale at N Kr. 240-265 per metric ton f.o.b. Domestic prices in Canada range up to Cn. $45; offers to export markets, still few in number, appear to be based on Cn. $23.50 f.o.b. Vancouver.

The following table indicates broadly the delivered cost of brimstone of varying origin at principal consumers' destinations. The freights rates shown are either actual charters made at the end of June or reliable indications.

f.o.b. Country of origin	*U.K.*	*N.W. Europe*	*France (Mediterranean)*	*India*	*Australia*
U.S.A. $24-25 ...	(43s.) £10¼-11⅛	(40s.) £10⅝-11	(45s.) £10⅞-11¼	(75s.) £12⅜-12½	(65s.) £11⅞-12¼
Mexico $21.50-24	(43s.) £9⅞-10¼	(40s.) £9¼-10⅜	(45s.) £10-10⅞	(75s.) £11½-12⅜	(65s.) £11-11⅞
Italy Lire 23,000*	(25s.) £14⅝	(22s.) £14½	(20s.) £14⅜	(50s.) £15⅞	—
Canada Cn $23.50	(60s.) £11½	(55s.) £10⅝	(55s.) £11¼	(70s.) £12	(60s.) £11½

Freight indications ( ) have been reduced to f.i.o. terms to provide a common basis for comparison. * Per metric ton.

to Rotterdam, the latter at a freight of $3.50.

In France Société Nationale des Pétroles d' Aquitaine is reported to effect domestic sales at prices ranging from Frs. 12,000-14,000 per metric ton. Now that the production at Lacq is mounting, sales to export markets for delivery in the second half are being negotiated. Prices are based on the landed prices of United States and Mexican Frasch sulphur and a price pattern reflecting some benefit of the lower cost of transportation from Lacq to major markets, is beginning to emerge. It is significant that Société Nationale des Pétroles d' Aquitaine are determined eventually to supply the lion's share of European sulphur demand, but equally the immediate aim appears to be to obtain the highest possible price compatible with new business being secured and in so doing to avoid a further deterioration of the world price level.

In Belgium and Holland recovered sulphur is reported to be on sale at BFrs. 1,500-1,600 and Dfl. 115-120 per metric ton, respectively; in Western Germany the price of brimstone recovered by Ruhrgas A.G. from spent oxide and by oil refineries are reported to range from DM. 125 to DM. 135 per metric ton. In Sweden prices have weakened slightly, mainly as the result of intensive sales efforts by United States suppliers. Domestic sulphur supplies recovered from oil shales by Svenska Skifferolje A.B. are priced at SKr. 180-200 per metric ton; advantages of delivery to users works warrants this slightly higher price compared to imported supplies from the United States and from Norway. Sulphur recovered by Orkla Metal A.S. from cupreous pyrites at Lökken, Norway,

Pyrites

A further reduction in the price of European pyrites takes effect on 1st July. The price of Rio Tinto, Tharsis and other Spanish crude pyrites has been reduced by five shillings and is now 77s. 6d. per metric ton f.o.b. basis 48%S, and that of Rio Tinto concentrates 67s. 6d. A commensurate reduction has been made by Cyprus Mines Corporation whilst Portuguese pyrites formerly 75s. are now priced at 72s. 6d. At the present level the lesser differential compared with the price of Spanish pyrites was thought to be more realistic. The competitive strength of Spanish pyrites vis-a-vis other pyrites and brimstone has been further improved by an increase in April of the controlled domestic price to Pesetas 266 per metric ton, Pesetas 50 more than hitherto. This reflects the Spanish Government's wish to help maintaining the position of the pyrites industry in its principal markets and probably also to indicate that in case of need it was prepared to bring even stronger measures into play.

Over the past two years successive price reviews the last one—of 10s. per metric ton becoming effective on 1st January, 1958—have brought down f.o.b. prices of European prices by about 22%. This progressive reduction of the cost of sulphur in pyrites, despite the worsening value of cupreous and non-cupreous pyrites residues has practically eliminated the unchallenged advantages of brimstone which existed in a number of markets. Nevertheless, there still remain, even where price parity has been achieved, the intangible advantages of brimstone use and the serious considerations of the heavier capital cost of pyrites plants.

Despite reduced exports of Canadian pyrites to the United States, pressure of supplies is no greater than usual as activity in non-ferrous metallic ores has slowed down. Cheap transatlantic freight makes this material, which is available at $2.40 per short ton ex-mine and from $3.60-$5.50 f.o.b., highly competitive. Demand for cupreous pyrites from Turkey and Cuba appears to have slackened. Pyrites concentrates from the flotation plant of the St. Patrick's Copper Mines in Avoca, Eire, are now on sale and despite somewhat high zinc values, are reported to attract interest.

Freights

Minor fluctuations apart, the freight market in recent months has remained weak. From 63.3 at the end of March the voyage index of the United Kingdom Chamber of Shipping (1952=100) declined to 62.7 in April and advanced to 64.6 in May.

There has been no significant change in the volume of chartering for the movement of basic raw materials such as pyrites, sulphur and phosphate, and the slackening in steel production has caused a contraction in the volume of iron ore movement.

From the United States and Mexican ports in the Gulf of Mexico spot charter for sulphur to the United Kingdom in an 8,000 ton vessel are reported at 47s., whereas to Rotterdam an 18,000-ton vessel was secured at $3.50 f.i.o. and to North France at 37s. 8d. European pyrites freights appear to have slightly hardened. The rates for larger vessels remained unchanged: 8,000 tons vessels from Huelva to Hamburg/Rotterdam/Antwerp paying 22s. 6d., and similar size vessels from Cyprus, 25s. 5d.-26s. 6d. The smaller "handy" sized vessels of 2,500-5,000 tons have, however, become scarcer and compared with 28s. at their lowest to the United Kingdom, recent fixtures entailed paying 32s.-35s. and to difficult ports even more. These rates are significant in assessing the shipping prospects for recovered sulphur from Lacq.

Wide variations in distant rates have become a feature of the depressed freight market. The sulphur freight rate from the U.S. Gulf to Australia at 85s. compares with a similar cargo to India (East coast) at a recent charter rate of 75s. Sulphur from China (Tientsin) to Australia (East coast) has been quoted at 52s. 6d.

Brimstone

Production of Frasch sulphur in the United States has been further cut back by producers to a monthly level of about 425,000 tons, 10% less than six months ago. Supplies of imported and recovered sulphur are taking an increasing share of the United States domestic market, which, under the adverse effects of lower industrial activity has contracted by about 6%. Stocks of Frasch and recovered sulphur continue to mount and are expected to reach 5 million tons during the summer months. In Mexico production is at present at an annual rate of 1¼ million tons, 25% more than in 1957. Further expansion is expected as a result of Gulf Sulphur Corporation's aim to achieve an average daily output of 1,000 tons by the end of this year. After again postponing the completion date of their new Frasch plant, Texas International Sulphur Company are no longer expected to be able to start regular production this year. Export and domestic shipments are being maintained at a high level and additions to stock piles are relatively low. Stocks are currently estimated to total about three-quarters million tons.

Italian output of fused sulphur, which in 1957 averaged 14,754 metric tons a month, totalled 12,791 metric tons in February 1958. Since then fused sulphur production has continued at this lower level, whilst at the same time provision has been made for the greater use of crude sulphur ore in sulphuric acid manufacture. Domestic consumption accounts for about 10,000 tons a month but exports are little more than one-quarter of last year's monthly average of 11,167 metric tons. In the four months period up to April 1958, Ente Zolfi Italiani exported only 12,058 tons against 64,647 at the same time last year. The cutback in production has prevented a steeper rise in stocks which have this year increased only 8,000 tons to 212,627 metric tons at the end of May.

In Poland production of sulphur ore concentrates from native ores is reported to have risen to 2,000 tons per month. The 1958 output is expected to be 20,000 tons per annum refined sulphur. Work is progressing on a major sulphur deposit in the Ukraine about 40 miles south of Lwow which is part of the same geological formation as the Polish deposits.

The discovery of a "rich" native sulphur ore deposit in Northern Tasmania is reported,

but not details are as yet available. Development of the native sulphur ore deposit on Sinai Peninsula is reported to be progressing satisfactorily and ore dressing and refining plant, to sustain a daily output of up to 300 tons sulphur, is expected to be installed in the course of next year.

Recovery

Production of recovered sulphur in the United States is expanding steadily, despite the lower oil refinery activities and lesser Middle East crude imports. The present annual production rate of 640,000 tons represents only about 65-70% of capacity installed at natural gas cleaning plants and oil refineries.

In Canada the provision of gas cleaning and sulphur recovery plants is progressing rapidly but not as fast as new discoveries and development of new sour gas wells. This year a significant increase in the volume of cleaned gas deliveries is expected which will be reflected in higher sulphur recovery, probably totalling one-quarter million tons, which is expected to meet all demands in Western Canada and spur individual producers into promoting exports. The provision of new gas cleaning and sulphur recovery units by several producers, notably Jefferson Lake Sulphur and Texas Gulf Sulphur Companies, at the major gas fields, near Calgary and Okotoks respectively, emphasises the imminence of Western Canada's sulphur surplus. In Eastern Canada sulphur recovery at oil refineries in Montreal, at Port Colbourne Nickel refinery and at Noranda Mines' pyrites sulphuric acid plants, is rapidly approaching an annual rate of 100,000 tons and so displacing about one-quarter of United States imports.

At oil refineries throughout the world new sulphur recovery capacity is coming on-stream or is projected. The programme of the British Petroleum Company and its subsidiaries and associates is typical: at the Hamburg oil refinery a sulphur recovery plant has been operating since last September, in the United Kingdom at the Isle of Grain refinery a plant is newly commissioned, and in Italy at Porto Marghera a hydrofiner is being built which will extract sulphur from 6,500 barrels of gas oil a day. In Africa, Socony Vacuum Oil Company have commenced construction on a plant to recover sulphur at a daily rate of 20 tons. The sulphur recovery plant at Kirkuk which has been ordered by the Development Board from Messrs. Ralph M. Parsons, of Los Angeles, will extract 300 tons daily from sour natural gas, the first plant to utilise the sour gas resources of the Middle East. Until Iraq develops its own sulphur using industries, India, the Middle-Eastern and East African countries are likely to benefit most from this new source of sulphur supply.

At Lacq recovered sulphur output is being raised to initially 17,000 tons monthly when the new sections of the plant are started up. At present monthly production is 6,000 tons and when the entire second unit is working in October it will be 30,000 tons per month.

Pyrites

World supplies are plentiful and mine capacities substantially exceed the present level of demand. Shipments by Spanish producers, notably by the Rio Tinto and Tharsis Companies, are reported to be about 20% below last year's level. Despite the weakness of the market, important mine developments are in progress or projected. In addition to work done by the major Spanish producers, Cie Francaise des Pyrites de Huelva and Cia. Minera San Telmo are planning to modernise installations and extending mine workings.

Production and exports from Portugal which in 1957 fell 25% have further declined in recent months. In Cyprus pyrites production has not so far been seriously affected by the political unrest. Cyprus Mines Corporation has aligned the rate of mining cupreous pyrites with demand for copper and pyrite concentrates. The Hellenic Mining Company, now able to ship from a new pier, has also reduced mining and beneficiation from last year's peak level.

Amongst Scandinavian producers, Boliden's output appears to be little changed from last year's peak of 447,000 tons pyrite concentrate. In Norway, production is generally lower although some individual mines whose production is directly linked with consumers' needs appears to be less affected. In Canada by-product pyrites shipments are curtailed but as the result of the lower level of non-ferrous metal ores production, the supply picture remains balanced. Pyrite and pyrhotite production in Japan has been maintained during recent months at last year's level of 3.1 million tons. Lower sulphuric acid needs are, however, expected to affect pyrite sales later this year.

UNITED STATES SULPHUR

Frasch Sulphur Production

Production of Frasch sulphur in the first quarter* of the year amounted to 1,305,946 tons compared with 1,406,898 tons in the corresponding period of 1957 and 1,379,683 tons in the preceding quarter, a decrease from the first and fourth quarters of 1957 of 7.2% and 5.3% respectively. The reduced level of production represents an effort on the part of producers to keep production more closely in line with the lower level of sales.

Despite this voluntary control, stocks at the end of the first quarter had risen to 4,620,947 tons, an increase of 198,000 tons during the quarter and 518,000 tons since March 1957. This deterioration of markets and their effect on stocks is shown in the following table :—

	Frasch production '000 tons	% *Change*	*Apparent Sales*	% *Change*	*Stocks*	% *Change*
1st Quarter 1957 ...	1,406.9	−6	1,241	−15.5	4,102	+28
4th Quarter 1957 ...	1,379.7	−1.9	1,230	− 1	4,222	+ 3
1st Quarter 1958 ...	1,305.9	−7.2	1,107	−11.8	4,621	+12.6

*Comparison with corresponding period of previous year.

Apparent sales in February of 334,778 long tons reached the lowest level for over six years but it is interesting to note that apparent sales of 429,134 tons in March nearly equalled production of 429,475 tons. Texas Gulf Sulphur Company's statement of income for the first quarter of 1958 reflects the sales difficulties being experienced in the industry. Gross revenue from sales declined by 32% from $17,138,890 in the first quarter of 1957 to $12,138,178 in 1958, at the same time expenses on selling and administration rose from $1,050,510 in 1957 to $1,210,478. Net income fell from $5,630,691 to $3,472,487 whilst earnings per share stood at $0.347 in 1958 compared with $0.562 in 1957. No shipments have yet been made by the subsidiary Compania Exploradora del Istmo, S.A. Installations at the Fannett Dome were completed at the beginning of the quarter although production is not expected until later in 1958.

Earnings of Freeport Sulphur Co. in the first quarter also showed a decline to $2.9 million from $3.1 million in the same period of 1957 with earnings per share of $1.18 compared with $1.27. Reduced earnings have not affected the company's long term developments, and construction work has started on the Grand Isle project which should begin production in 1960.

Recovered Sulphur

Recovered sulphur production from industrial and natural sour gas sources in the United States and Canada continues to grow. United States production of recovered sulphur in the first quarter of 1958 amounted to 153,957 long tons compared with 120,954 tons in the same period of 1957, an increase of 27.3%. These supplies are assuming increasing importance as more consumers come to rely on regular local sources of sulphur.

The new 50 tons per day plant of the American Oil Co. started production at the end of 1957 whilst that of Pan-American Petroleum Corporation at Cottonwood Creek, currently producing 20 tons per day of recovered sulphur, began operations in March. The Commerce Oil Refining Corporation of Jamestown, Rhode Island, has announced that a 30,000 tons per annum recovered sulphur plant is being constructed by the Fluor Corporation of Los Angeles and should be completed by mid-1959.

Apparent consumption of recovered sulphur continues to rise and some of this expansion is at the expense of Frasch sulphur. Sales during the first quarter of 1958 of 147,564 were 19,069 tons (14.8%) greater than those in the first quarter of 1957. Stocks in the hands of producers rose to 163,462 tons against 111,905 tons in March 1957, but these are not yet too large considering the annual rate of consumption and the large number of suppliers.

Consumption

Deliveries of Frasch sulphur to the home market were only 789,000 tons, a decline of 161,000 tons, but deliveries of recovered and imported sulphur expanded so that apparent consumption of brimstone was 1,073,956 tons, a decrease of 115,000 tons compared with the same period in 1957. There appears to have

★ For monthly details see Statistical Appendix.

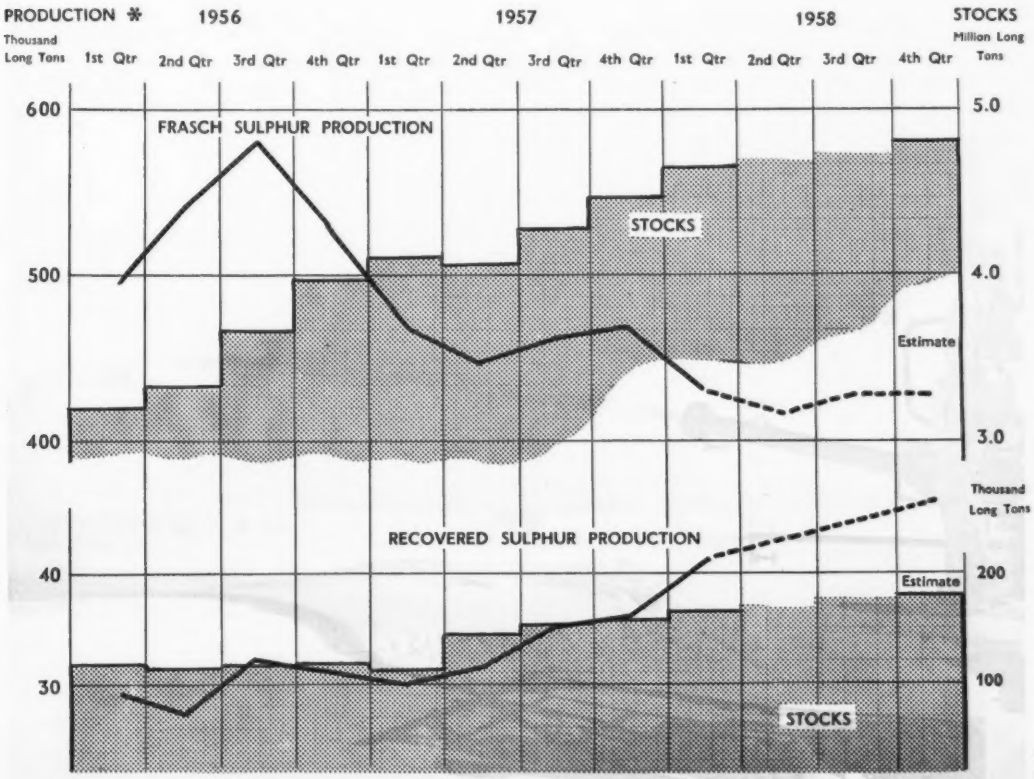
been some reduction of consumers' stocks, especially at the sulphuric acid plants and actual consumption is estimated to have declined by only 50,000-60,000 tons.

Sulphuric acid consumption for the first quarter of 1958, amounting to 3.93 million tons (100% H_2SO_4), was 1½% lower than for the same period in 1957.

In the light of many pessimistic opinions expressed on the fortunes of the sulphuric acid industry this decline appears much smaller than was anticipated. Even so at existing levels of demand there is considerable excess capacity and there is a strong feeling that any further restriction in production would adversely affect the economics of manufacture and result in an upward price movement. The major cause of the decline is the low level of activity in the steel industry which, in the first quarter, was working at less than 60% capacity.

Buoyancy of textiles and high tenacity tyre cord has been helping to sustain the demand for acid. Also it appears that despite the anticipated 10-12% decrease in fertilizer demand, the improved spring weather and better prices for farm produce have resulted in increased business. Low steel production has limited the availability of by-product ammonium sulphate, with the result that synthetic ammonium sulphate producers have increased their use of sulphuric acid. Demand for fertilizers in the export market continues at a high level despite European competition.

Non-acid demand for sulphur weakened in the first quarter, partly because activitiy in the pulp and paper industries had contracted to around 85% of capacity, compared with 96% in the first quarter of 1957. Demand from the rubber industry continued to be affected adversely by the recession in the automobile industry.



Photograph by courtesy Freeport Sulphur Company. Vat building at Grand Ecaille.

Trade

Imports from Mexico amounted to approximately 138,000 tons in the first quarter against 109,823 tons in 1957, an increase of 25.7%. As a proportion of United States Frasch sulphur consumption during the January/March period these imports represented over 12% compared with less than 9% in the same period of 1957.

Frasch sulphur exports totalled 318,519 tons, an increase of over 28,000 tons compared with the first quarter last year, although this period is not a good indicator partly because shipments to Canada are generally erratic at this time of year. Australia and France showed significant increases compared with the first quarter of 1957.

Deliveries of sulphur to Australia rose 250% to 41,000 tons, and those to New Zealand rose to approximately 12,000 tons, an increase of 50%. Exports to the United Kingdom fell by 10,000 tons to 54,000 tons compared with the first quarter of 1957. United States exports to the Union of South Africa during the first quarter were affected adversely by Mexican competition and declined from 30,000 tons in 1957 to 16,000 tons in the first quarter of 1958.

Following the formation of the Sulphur Export Corporation by Texas Gulf and Freeport Sulphur Companies it has since been extended to cover the overseas activities of all four U.S. Frasch sulphur producers.

Summary

(a) During the first quarter of 1958 production of Frasch and recovered sulphur declined by 5.5% and 3.8% from the first and fourth quarters of 1957 respectively to 1,460,000 tons.

(b) Apparent sales of Frasch and recovered sulphur amounted to approximately 1,254,000 tons compared with 1,369,000 tons in the same period of 1957. The decline was due entirely to lower domestic Frasch consumption. Stocks of Frasch and recovered sulphur rose by 205,000 tons compared with the previous quarter and 570,000 tons for March 1957, to a level of 4,784,400 tons.

(c) Exports of Frasch sulphur increased by 28,000 tons over the first quarter of 1957 to 318,519 tons and there were variations in the pattern of distribution.

(d) Imports of sulphur from Mexico continued to rise and amounted to approximately 138,000 tons compared with 109,823 tons in the first quarter of 1957.

Concern over the effects of the United States recession on the sulphur and sulphuric acid industries and rethinking on the existing pattern of supply and demand, have been the dominating features so far during 1958. The United States' economy has proved much tougher than many observers, still looking back to the pre-war era, believed. The failure of the administration to be panicked and a still fairly buoyant consumer demand, together with an improved agricultural situation, appear to be exerting a stabilizing influence and the bottom of the recession may have been reached. Moreover, it is interesting to note that many business men and economists are seriously questioning the reliability of certain accepted economic indicators. Remembering the psychological element in any recession, examination of this point may prove of considerable importance.

Confidence in the future of the Frasch sulphur industry is reflected in the large research and development effort that is being exerted by the producers. This is sound essential policy but expansion into recovered sulphur and greater diversification will be of increasing importance. When talking of recovered sulphur in the United States, developments in Canada cannot be ignored especially as United States sulphur producers, notably Jefferson Lake and Texas Gulf Sulphur Companies, are taking a very active part in them.

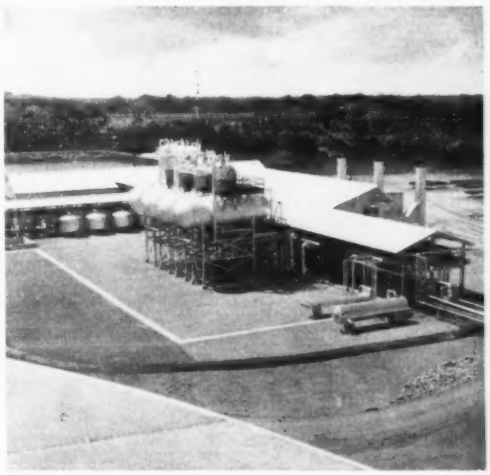
The establishment of Mexico as a major brimstone supplier to a sector of the U.S. acid industry and the continued growth of recovered sulphur have altered the almost traditional picture of U.S. sulphur supply. This is not a passing feature although the opinion is expressed that present difficulties of the Frasch sulphur industry are due to the low level of economic activity and that when the economy eventually resumes its upward trend the old conditions will be re-established. Increasingly therefore, the U.S. Frasch sulphur producers are having to adjust their policies with a view to maintaining as big a share of their still large markets throughout the world.

SULPHUR IN MEXICO

THE achievements of Mexico's young sulphur industry under the adverse conditions of world sulphur trading and oversupply in recent months, underline the strong position which the industry has built up and the confidence which it has earned. Inevitably, many developments which in an old-established industry are routine events, attract attention because of their novelty; nevertheless, the continued expansion of production, of export and domestic sales and of new investment is remarkable in itself, and, except in respect of investment, contrasts with the present recession in the United States sector of the Frasch sulphur industry. Sulphur production in Mexico during the first five months of the year represent an annual rate of 1¼ million tons, an advance of 31% compared with the first half of last year. Exports, the basis of the industry's prosperity, rose to an annual rate of one million tons, an improvement of 25% compared with the corresponding picture in 1957. Production of Frasch sulphur is provided by the Mexican operating subsidiaries of Pan-American Sulphur Company, Gulf Sulphur Corporation, and Texas Gulf Sulphur Company, while exports continue to be sustained by the two first named companies. Sulphur recovered from natural and oil refinery gases by PEMEX and some native sulphur ore output cover most of the domestic needs which are rising past the present level of usage of 80,000 tons per annum.

PAN AMERICAN SULPHUR COMPANY

Forecasts of production and sales during 1958 made by Mr. Harry C. Webb in his annual statement are borne out by the results of the first quarter: output of 208,552 tons exceeds the projected rate of 800,000 tons per annum. The installations at Jaltipan dome are capable of a substantially higher level of production and with the completion of a second loading installation at Coatzacoalcos the company has the means of loading up to 1½ million tons, should world demand and markets permit the company to raise output and deliveries to that level. Practically the entire output is filtered enabling the company to sell yellow sulphur containing at least 99.5% S, not more than 0.25%-0.3% C, and low ash and moisture. Shipments in the first quarter totalled 175,000 tons compared with 141,000 tons in 1957, and almost the entire tonnage was destined for export, the major importers being the United States 60.2%, United Kingdom 14.3%, France 16.8%, Australia 6.9%, others 1.8%. The slight increase in April and May in the company's level of shipments fully justified the maintenance of the production rate which in May amounted to 78,221 tons, the highest monthly total this year. Despite the reduction in prices net earnings improved to $760,849 compared with $731,445 during the same period of 1957. The level of stocks which the company wishes to improve is now estimated to stand at about 580,000 tons, 40,000 tons more than at the end of last year.



Gulf Sulphur Corp. Water treatment installations.

GULF SULPHUR CORPORATION

Technical difficulties, mainly with bleed-wells, are reported to have been successfully overcome and in recent months output at Las Salinas dome has ranged from 19,000 to 21,000 tons per month, average production during March having exceeded 700 tons per day. In the first quarter of 1958 production totalled 54,719 tons, a level which is being slightly exceeded in the second quarter. A new boiler has been installed and encouraged by the progress made and as the result of strengthening the technical direction of the company's affairs, the management has expressed confidence in being able to raise output by mid-

summer to average 900 tons per day, and by the end of the year to an average daily rate of 1,000 tons. An annual rate of production of about 300,000 tons would not only place the company on a sounder basis of profitability but would accord more closely with the existing order book. To meet customers' requirements regularly and efficiently, the company has been obliged to draw on stocks and it is intended to raise substantially their present low level. The improved quality of some of the more recent wells has been maintained and, as it meets customers' requirements, this part of the output is not subjected to filtering. In the first quarter shipments totalling 61,500 tons were directed to customers in the United States, France, Australia and Israel.

TEXAS GULF SULPHUR COMPANY

Production of Frasch sulphur at the Nopalapa dome is being held to a monthly rate of about 7,000-8,000 tons, a level of operations which could be increased substantially should the need arise. The entire output continues to be stockpiled and to date no shipments have been made. The labour dispute which has been troubling Cia. Explorado del Istmo, S.A., appears to have been settled as far as the basic points in the dispute are concerned.

TEXAS INTERNATIONAL SULPHUR CO.

The Mexican affiliate of this company Central Minera, S.A., is at present erecting a Frasch system extraction plant on its dome at Texistepic. The plant which was formerly owned by the Standard Sulphur Company is now expected by company officials to come on stream in August or September. The two months' deferment is believed to be occasioned by financial and technical considerations. Central Minera drilled a total of 78 wells during 1957 and having determined ore reserves of five million tons sulphur is now planning, according to the company's official report to the Mexican Government, to operate th 500 tons brimstone per day plant, once test production is complete.

PETROLEOS MEXICANOS

This nationalised petroleum company is reported to be producing 3,500 to 4,500 tons of pure sulphur per month at the gas-sulphur separation plant at Poza Rica which provides an annual production of approximately 40,000 tons. A new unit is being installed which should increase the present rate of production to between 5,500 tons and 6,500 tons monthly, depending on the volume of gas throughput.

NEGOCIACION MINERA DE AZUFRE

Production of "hand" mined sulphur at Los Cerritos, San Luis Potosi is running at approximately 1,500 tons per month and is expected to continue at this rate. The installation of new machinery and handling equipment is under consideration and if realised would enable mines to increase production. The management states that no difficulty has been experienced in selling the output on the domestic market.

MEXICAN GULF SULPHUR COMPANY

This pioneer of the Mexican Frasch Sulphur industry officially ended its existence in April when the Export-Import Bank and the Mexican Government loan agencies offered the company's plant, marine equipment and other property for sale at public auction on April 11th.

From the outset it appeared that this sale would be difficult due to the terms set out in the mortgage which would not permit the acceptance of a bid lower than the official valuation. The official inspectors placed a value of $1,656,000 on the plant whilst reliable sources in Mexico and the U.S.A. stated that the equipment on the second-hand market would be worth $350,000 to $400,000. It has since been learned that no private bid was received and the Mexican Government acquired the plant for approximately $2,000,000.

Acquisition of plant by the Government has aroused considerable interest and conjecture as to whether it may eventually lead to the Government's direct participation in the sulphur industry. In this respect Government agencies have already carried out investigations to determine prospects for sulphur in the Isthmus of Tehuantepec. Moreover the payment of a sum considerably greater than valuation is unlikely to be allowed to pass by without some attempt to justify the action. Government entry into the industry as a competitor is likely to go a long way towards silencing those trade unionists who have been demanding nationalisation of the sulphur industry. To date the Government has not made public its plans for the use or development of the newly acquired plant, but it is expected that it will co-ordinate its activities with the private sector of the industry.

UNITED KINGDOM SULPHUR

THE first quarter of 1958 confirmed the slackening trend in sulphur consumption which was becoming apparent over the latter part of 1957. Consumption in all forms totalled 243,000 tons which although fractionally greater than the tonnage used in the last quarter of 1957 showed a decline of 1½% compared with the first quarter last year. Brimstone accounted for 42% of total consumption, pyrites 19%, anhydrite 17%, spent oxide 13%, whilst the remaining 9% was made up of zinc smelter gases, recovered sulphur and filter cake.

Details of consumption are given in the following table :—

	1st Quarter 1958	4th Quarter 1957	% Change	1st Quarter 1957	% Change
Elemental Sulphur :—					
Total Acid	87,274	84,212	+ 3.7	86,700	+ 0.7
Imported	63,785	72,062	+ 5.6	75,800	−15.8
Recovered, H_2S and filter cake ...	11,237	12,150	− 8.5	10,900	+ 2.8
Non-Acid	26,100	26,300	− 0.7	28,700	− 9.1
Total elemental	113,374	110,512	+ 2.7	115,400	− 1.7
Pyrites	96,659	92,915	+ 4.1	95,900	+ 0.9
Spent Oxide	67,538	67,592		68,700	− 1.7
Anhydrite	193,111	188,476	+ 2.4	188,800	+ 2.3
Zinc Concentrates	36,664	42,644	− 14.2	42,300	− 13.6

This decline is particularly significant as the first quarter of the year is normally one in which the sulphur using industries show a high level of activitiy. Moreover the reduced consumption was not limited to a few industries but, with the exception of titanium and detergents, spread over almost the whole range.

Although the use of brimstone for acid manufacture showed a considerable increase over the last quarter of 1957 and a slight increase over the same period last year, total brimstone use, compared with the first quarter of 1957, declined by 2,000 tons due to lower non-acid consumption.

Consumption of pyrites of 96,700 tons was relatively stable and largely due to the high levels of acid production. This apparent stabilization does not mean that the decline in pyrites use has been halted, but only that at the prevailing rate of acid production some pyrites units which will no longer be used when the new brimstone plants come into operation in the course of 1958 or by 1959, were still operating.

By-product acid output at zinc smelters declined considerably in the first quarter of this year as the industry's activity remained adversely affected by the low price of the metal.

Anhydrite consumption rose but only within the limits of plant capacity which, at the present rate of activity, appears to be almost fully employed. With increasing nitrogen capacity from sources other than ammonium sulphate in response to the demand for higher analysis fertilizers, the demand for anhydrite in the direct manufacture of ammonium sulphate may decline.

Supplies

Total imports of sulphur as brimstone and pyrites during the first quarter of 1958 amounted to 107,080 tons compared with 114,209 tons in the preceding quarter and 124,749 tons in the same period of 1957.

Imports of brimstone at 81,580 tons were 7.3% lower than the first quarter of 1957 but 27.1% up on the preceding quarter. Brimstone accounted for 76.2% of total sulphur imports in the first quarter of this year compared with 70.5% in the same period last year. Supplies from the U.S.A. amounted to 66,143 tons and Mexico 15,332 tons, whilst the average value of brimstone imports from the U.S.A. and Mexico was approximately £12 2s. compared with £15 13s. per ton in the first quarter of 1957. The lower f.o.b. prices and continued favourable freights have led to this price decline.

Pyrites imports of 51,704 tons declined heavily from the previous quarter when they totalled 106,608 tons; this may have been partly due to consumers running down stocks. The average value of imports was approximately £6 5s. per ton compared with £7 17s. in the same period of 1957. Cyprus, Spain and Canada were the only sources of supply with 27,975, 19,529 and 4,200 tons respectively. The

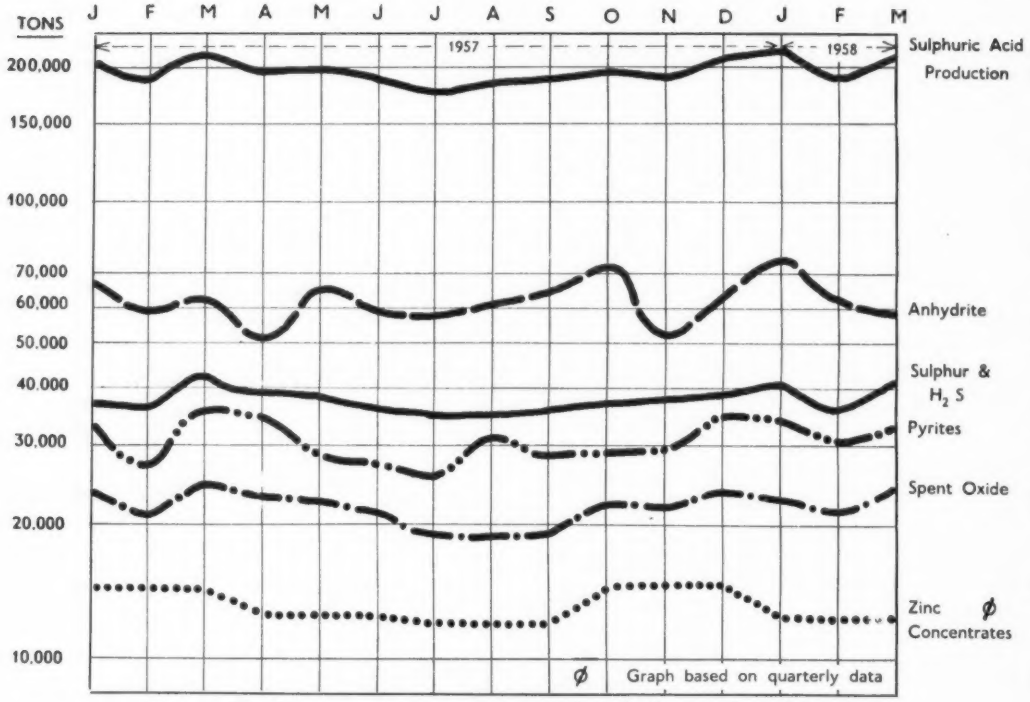


Fig. 5. Monthly consumption of raw materials including regular sulphur and sulphuric acid consumption.

material imported from Canada is believed to have been among the last to be received from Britannia Beach which closed down in March.

Sulphuric Acid Production*

Production of 611,514 tons (100% H_2SO_4) during the first quarter was almost 1% up on the preceding quarter and compared with 605,728 tons in the same period of 1957. This rate of production represents 89.6% of capacity.

Capacity of 682,440 tons in the first quarter of 1958 was 2.5% less than in the same period last year, the decline being entirely due to a progressively reducing chamber and tower acid capacity. The fractional increase compared with the last quarter of 1957 was caused by a rise of 4,000 tons in contact acid capacity. During each of these periods there has been little variation in proportion of production based on chamber and tower and the contact processes, with 23% and 77% respectively of total output.

The percentages of raw materials used in the production of sulphuric acid were as follows:—

	1st Qtr. 1958 %	*4th Qtr. 1957* %	*1st Qtr. 1957* %
SULPHUR :—			
Imported Brimstone	35	33¼	34¼
Recovered, H_2S and filter cake ...	5	5½	5
SULPHUR IN :—			
Pyrites	21½	21	22½
Spent Oxide ...	15	15¼	14¼
Anhydrite	18½	18½	17¼
Zinc Concentrates	5	5¼	5¼

Consumption of brimstone for acid production is the only notable feature showing growth at the expense of other materials, a trend which must increase as brimstone plants now under construction displace the older pyrites units.

The increase in capacity of 4,000 tons during the quarter is attributed to the new plant of British Titan Products at Grimsby based upon brimstone and which came on-stream in January.

Sulphuric Acid Consumption

Consumption of sulphuric acid during the first quarter of the year amounted to 615,324 tons, a decrease of just over 2% compared with the same period last year and only 1.4% greater than the last quarter of 1957.

* We are indebted to the National Sulphuric Acid Association for information placed at our disposal.

The interesting feature of the consumption figures given in the following table is that compared with the first quarter of 1957 the decline in consumption was extended to all uses with the exception of titanium and soap and detergents.

	1st Qtr. 1958 000 tons	% Change*	4th Qtr. 1957 000 tons	% Change*	1st Qtr. 1957 000 tons
Fertilizers	237	− 2.4	232	− 4.5	243
Chemicals	72	− 7.7	76	− 2.5	78
Titanium dioxide	87	+10.1	85	+ 7.6	79
Rayon and Transparent paper ...	65	−13.3	61	−19.7	75
Metallurgy	32	− 5.8	33	− 2.9	34
Oil Refining	14	−12.5	15	− 6.3	16
Dyes	20	−13	19	−17.4	23
Soaps and Detergents	29	+31.8	28	+27.2	22
Plastics	10	—	9	−10	10
Miscellaneous	48	—	49	+ 2.1	48
Total	615	− 2	607	− 3.3	628

* The percentage changes refer to the 1st Quarter of 1957.

Particularly noteworthy is the reduced use of acid in fertilizers, oil, rayon and transparent paper.

The decline in the demand for sulphuric acid by the fertilizer industry was the first since the second quarter of 1957. Moreover, then only superphosphate manufacture was affected, but in the first quarter of 1958 the decline also extended to ammonium sulphate. In the case of ammonium sulphate the fall of nearly 2,000 tons is probably caused by increased use of higher analysis fertilizers not based on ammonium sulphate. There is not yet sufficient data available to state whether or not this is the beginning of a definite trend but the coming on-stream of the Stanford-le-Hope plant of Fisons Ltd., and new nitrogen capacity of I.C.I. Billingham, in the autumn should provide further confirmation.

The consumption of sulphuric acid by the titanium dioxide industry, at 87,482 tons, in the first quarter was 17.2% greater than in the corresponding period last year but only 2.4% greater than in the preceding quarter, when consumption was 85,575 tons.

The chemical and associated industries are facing difficulties in domestic and export markets because of slackening demand and growing competition. However, due to intensive pursuit of the post-war investment programme the chemical industry remains basically strong.

Non-Acid Sulphur

Consumption of non-acid sulphur has declined from an estimated 26,300 tons in the preceding quarter to an estimated 26,100 tons in the first quarter of 1958; compared with the same period last year consumption has fallen by approximately 2,600 tons.

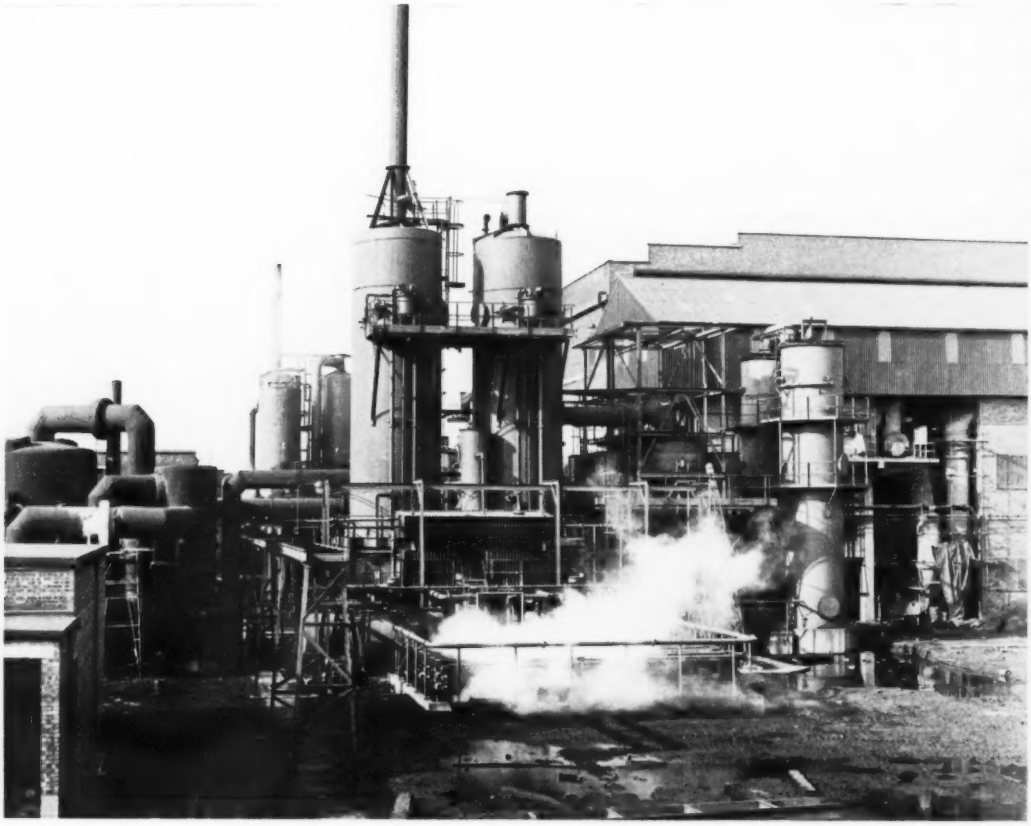
The major reason for this decline is to be found in the man-made fibres industry where output during the first quarter was 12% lower than in 1957. Despite the active condition of the U.K. motor industry with its complementary demand for tyres, the increase of 12% in tyre cord demand was insufficient to make good the declines in other markets. Although demand for new products of the rayon industry is growing it is evident that capacity is still considerably out of phase with existing demand. It appears that a reappraisal of activity, both from quantitative and qualitative points of view, is necesary.

Summary

The two outstanding features of the United Kingdom sulphur and sulphuric acid industries apparent in the first quarter of 1958 are the slight but wide-spread decline in acid consumption and particularly the decline in acid use by the fertilizer industry.

It is not yet clear to what extent the change in the manufacturing pattern of the fertilizer industry is responsible but there are indications that the trend towards higher analysis fertilizers is adversely affecting the use of ammonium sulphate. Phosphoric acid consumption continues to increase although at a lower rate than in the past. These longer term trends imply a reduced rate of growth in demand for sulphuric acid by the United Kingdom fertilizer industry.

The trend away from pyrites to brimstone continues although at present the high level of acid production demands continued operation of pyrites units. This trend may be expected to quicken as brimstone plants now under con-



British Titan Products Co. Ltd. General view of the No. 4 sulphuric acid plant.

struction come on-stream to replace the smaller and less economical pyrites plants. An example of this is provided by Messrs. Fison's Ltd., whose new brimstone acid plant at Immingham, now on-stream, will gradually replace pyrites acid output at their smaller factories. Other brimstone burning plants under construction or which have come on-stream since the end of the first quarter include units for British Titan Products Co. Ltd. (two plants one of which will have a 250 t.p.d. capacity), Cowburn and Cowpar Ltd., and Laporte Industries Ltd.

The sulphur using industries of the United Kingdom continue to benefit from low commodity prices and favourable freights. This is not, however, reflected in improved demand, since there has been a distinct slackening in industrial activity and according to the recent Federation of British Industries survey many companies are not optimistic about immediate prospects. Although it is now the time of year when seasonal factors cause a decline it appears that the sulphuric acid industry now accepts the view that during the summer this decline may be as much as 10 to 15% in contrast to last year's 2 to 3%.

The customary rise in the level of general industrial activity in the autumn will of course show up in the results of the sulphur using industries. It is not thought, however, that the extent of the upswing will provide a valid pointer for the immediate future. This may become evident in about twelve months time when a number of developments, notably those in the fertilizer industry, have become more pronounced. Then, in addition to the likely level of sulphur demand emerging, a clearer picture of import requirements should also be available as the many potential and actual sulphur recovery projects of the various sectors of the U.K. fuel and metal industries come nearer fruition.

Developments in India

General

Some years ago when the nation-wide programme of scientific and industrial research was being planned there was considerable criticism of the expenditure on research that, to many, appeared too academic. Certain bodies of opinion felt, with some justification at the time, that the money would be better spent on the purchase of equipment, materials and knowledge from abroad. However, over the past two years the view of the original planners has been vindicated, as scientific and industrial research have become more closely geared to the requirements of agriculture and industry in the Second Five Year Plan.

Despite the still large proportion of knowledge and equipment that must be obtained from abroad, national achievements in the field of production and technology are making a significant contribution towards progress. This is nowhere more true than in the steel, fertilizer and sulphuric acid industries. The only sector in which a distinct policy has yet to emerge is in the provision of certain raw materials, and of these sulphur must assume paramount importance.

The current five year plan aiming at a balanced development of both agriculture and industry envisages an increase of nitrogenous fertilizer production to 1,600,000 tons, and superphosphate to 720,000 tons by 1961. Even these levels of production will, however, be considerably less than estimated consumption, and large imports of fertilizers will still be required. In view of India's foreign exchange difficulties it is important that these developments do not place too much strain on the currency reserves and as much as possible should be achieved from native resources.

About one-half of present sulphuric acid consumption is used in the fertilizer industry, and in 1955/56 amounted to 88,000 tons, of which 40,000 tons was used for ammonium sulphate and 48,000 tons for superphosphate. Although not all the increased nitrogenous fertilizer production will require sulphuric acid, total acid consumption by the fertilizer industry in 1960/61 is estimated at 320,000 tons. The following table gives a break-down of present and estimated Indian sulphuric acid consumption.

Sulphuric Acid use	*Tons (100% H_2SO_4)*		
	1955/56	*1960/61*	*Growth*
Ammonium Sulphate and Phosphate	40,000	120,000	200
Superphosphate	48,000	200,000	316
Steel Pickling, etc.	7,000	15,000	114
Oil Refining	7,000	10,000	43
Alums and Heavy Chemicals	15,000	24,000	60
Rayon	21,000	58,000	176
Miscellaneous	22,000	43,000	95
TOTAL ...	160,000	470,000	194

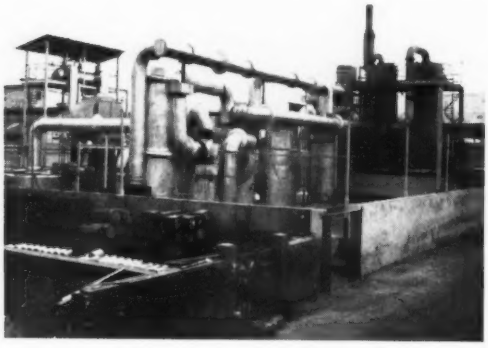
Total capacity in 1956 of the sulphuric acid industry amounted to 245,000 tons from 37 operating plants. Little of the acid produced is sold, most being used captively where it is produced. It is apparent, therefore, that capacity must be increased very considerably, and the Second Plan envisages a capacity of 600,000 tons by 1961.

In this programme of construction of acid plants, Indian research and training of technologists should result in a saving of foreign exchange, for much of the design and construction work is now capable of being carried out by Indians. An interesting example of this development was provided by the 75 tons per day sulphuric acid plant designed and constructed by D.C.M. Chemicals near Delhi in 1957.

D.C.M. Chemicals came into existence as a subsidiary of The Delhi Cloth and General Mills Company, when in 1942 the company was badly in need of sulphuric acid and phosphates. To meet this problem the management began the design and construction of the D.C.M. Chemical Works. The first acid plant of this Company was a two ton per day chamber acid unit, increased in 1943 to ten tons per day, although none of the new plants envisaged will be less than 25 tons. Construction of a superphosphate plant in 1945 led to the Company's first contact unit with a 12.5

ton capacity, followed by a similar plant in 1951. This latter plant is of particular interest as it was the first contact acid plant fabricated in India, although in 1956 a 30-ton per day plant was put up by the National Rayon Corporation.

Encouraged by their success with the earlier plant, D.C.M. Chemicals adopted the same policy of relying as far as possible on their own technical resources in the construction and design of the most recent plant. For the construction of this a separate "Projects Office" was established with all necessary engineers, draughtsmen, etc., to prepare plans and procure materials. The cost of imported materials and components was reduced to approximately 40% of the cost of the plant, and in the future, as Indian industry obtains the necessary knowledge and confidence, manufacturers should be even less dependent on imports. At present the new plant provides sufficient acid for the Company's requirements, and the two smaller plants have been closed



D.C.M. Chemical Works. General view of 75 tons per day acid plant at Delhi.

down. Acid production is used by D.C.M. Chemicals in the manufacture of superphosphate and alum, but with the planned increase in superphosphate capacity the demand for acid for this use will rise.

Although Indian sulphuric acid capacity is planned to increase from 245,000 tons to 600,000 tons, in view of difficulties, particularly foreign exchange, this figure is considered too optimistic and 480,000 tons by 1961 is considered more realistic. Indeed, due to economic difficulties or bad forecasting it may be necessary to adopt a system of priorities for plant construction, with those in integrated projects receiving most emphasis. The progress of the plan may receive assistance from encouragement given to private enterprise, but even here many of the same problems are encountered, and it appears that the plan is almost certain to fall some way short of targets.

As existing sulphuric acid production is based almost entirely on imported brimstone the increase in acid production must cause some anxiety over sulphur supplies. Imports are currently at an annual level of 100,000 tons and likely to reach 225,000 tons by the end of the current plan. Due partly to exchange shortage this is considered neither economically nor strategically desirable. Although a large part of this increase is due to fertilizers there appears little or no possibility of reducing sulphur requirements by varying the type of fertilizer produced.

From the foregoing it appears that given the present programme of industrial expansion and pattern of fertilizer production, Indian requirements of sulphur by 1961 may rise by over 100%.

Deposits of native sulphurous materials, despite extensive prospecting, do not show any indications of meeting India's needs in the future. Gypsum resources are already being exploited almost entirely for direct production of ammonium sulphate. If the latter could be further expanded they might possibly assist marginally in reducing acid requirements, but such a policy even if economically desirable would be very limited. Pyrites deposits show even less promise than gypsum as they are, in most cases, small and isolated, requiring very large capital expenditure on transport and equipment for development. This, despite the Minister for Industry's statement that the Government would spare no effort or money to locate sulphur anywhere in the country, cannot be seen at present to be economically wise. It is suggested that the effort and money could be more profitably employed in other directions. Recovered sulphur production from industrial gases and oil refineries, either in the end form of elemental sulphur or sulphuric acid, has been growing considerably in the world during the last few years. As India is steadily expanding her heavy industries such as at Rourkela and Neyveli and oil refineries

in Assam, Trombay and Bombay, these would appear to offer means of producing indigenous sulphur supplies. Developments along these lines are taking place in several instances, but it is felt that more might be done, particularly at oil refineries, and with growing technological independence such a programme should not prove too burdensome. Of course, much depends on sources of oil, but, even allowing for the low sulphur content of Assam oil, as the remainder comes from the Middle East fields, recovered sulphur capacity from the refineries could make a significant contribution to India's requirements. Mention of the Middle East indicates the further possibility that should Iraq's plans for an oil-based chemical industry come to fruition India may turn to that country as a source of sulphur.

Provided the major possibilities are realised, it is within the reaches of economic possibility that sulphur recovery plant could provide capacity for 40,000 tons of indigenous sulphur supplies by 1961/62. This quantity would meet approximately 17% of India's estimated import requirements by that date, and would be of considerable assistance to the whole economy and future industrial development should result in further increases.

The major problem of provision of equipment and technical knowledge for these projects remains, but the growing independence of Indian technological resources based upon research should improve the feasibility of such a programme. The challenge and opportunity exist, it will be interesting to see whether the Indian Government will act in a realistic manner.

ELEMENTAL SULPHUR IN JAPAN

Production and Consumption

Production of elemental sulphur in Japan during 1957 totalled 258,000 metric tons, an increase of 11,000 tons (4%) over 1956. These bare figures do not show the drastic changes in the supply position which occurred during the year. In the opening months of 1957 demand for sulphur was so great that all production resources of the industry were employed, and although the producers had raised their capacity to over 300,000 tons, they were still unable to meet the needs of the consumers. It was then estimated that the production for the year would total over 290,000 tons. During the late spring and summer, however, demand started to fall off sharply, due to the decline of activities of the rayon and staple fibre industries, whose production contracted between 30-50%.

The supply position was also affected by the recovery of carbon disulphide at several staple fibre plants. Operations started in April 1957 and are proving very successful, with recovery rates running as high as 40-50%.

Stocks held by producers and consumers at the end of the year are reported to have totalled 35,000 tons.

The distribution of domestic sulphur consumption in 1957 was as follows :—

	000 metric tons		*Change*
	1957	*1956*	%
Carbon disulphide ...	129	129	
Pulp	89	93	− 4
Synthetic fibre	13	11	+18
Other	18	22	−18
	249	255	− 2.4

The Sulphur Market in Japan

The relationship between producer and consumer is generally close and of long standing and although contracts are technically on a short-term basis, being signed for terms of three to six months, they are in fact valid for much longer periods.

In spite of the sharp fall in demand, the price remained at 22,000 yen* f.o.b. at mine throughout 1957 and did not fall until February 1958, when it was reduced by 800 yen per ton. Amongst factors contributing to the relative stability of prices are the refusal of the Government to sanction imports unless demand greatly exceeds supply and an agreement concluded between producers and consumers in April 1956 to co-operate over prices and supplies.

Many consumers have financial interest in the mines, and mindful of periods in the past when they have suffered acute shortages, the

* Yen 1009 = £1.

majority support the principle of close co-operation with the producers, both parties realising their mutual dependence. Nevertheless, it must be remembered that consumers are now buying at prices at least 65% higher than they would have to pay for imported sulphur.

Exports

Exports of sulphur, which totalled 5,792 metric tons in 1955, had fallen to 565 tons in 1956. They were increased in 1957 to about 4,000 tons distributed in small quantities to several countries in the Far East. While the cost of Japanese sulphur remains at its present uncompetitive level it is unlikely to have any significant effect on world markets.

New Refining Process

Satisfactory progress is reported on their new ore refining process by the Matsuo Mining Company, Japan's largest individual sulphur producer. Design and construction of a pilot plant with a capacity of 500 tons refined sulphur per month was started early in 1955. The plant, which came into operation in August of that year, consists of a brick-built furnace comprising distillation and heating chambers arranged alternatively in a set of batteries. The slight difference of pressure between the chambers is adjusted automatically and both charging the furnace with crude ore and drawing off the refined sulphur are continuous. The plant is designed to permit 96% recovery, 25% fuel consumption and 0.3 man shifts per ton of product and these targets have generally been obtained. Modifications to the original design appear to have been proved and construction may be started in the autumn.

Recovery from Oil Refineries

A novel feature of the Japanese sulphur industry and one which is likely to affect it considerably in the future is the recovery of sulphur at oil refineries.

The Idemitsu Kosan Co. Ltd., have recently started operation of a recovery plant at the Tokuyama refinery. The plant, which was designed by the Girdler Company of Louisville, U.S.A., and constructed by the Japanese Gasoline Company of Tokyo, has a capacity of 20 metric tons of elemental sulphur a day. Other oil refineries in Japan intend to produce sulphur or sulphuric acid from H_2S recovered at their refineries, while the Mitsubishi Petro-chemical Co., Mitsui Petro-chemical and Showka Denko Companies plan to produce ammonium sulphate using refinery gases. Before long, Japanese oil refineries can be expected to recover in various forms more than 90,000 tons of sulphur a year.

Conclusion

Developments in Japan's elemental sulphur industry in 1957 focussed renewed attention on its two major weaknesses: the high cost of production inherent in native ore refining and the industry's dependence on a high level of activity in pulp and man-made fibres manufacture. The present depression in the man-made fibres industry, the largest brimstone consumer in Japan, is due to a reduction in domestic and especially foreign demand following a period of rapid plant expansion. Generally the effects of changes in world trading conditions are much accentuated in Japan and the universal recession in man-made fibres manufacture has made a severe impact on the Japanese industry which is a leading producer of rayon filament and the largest world producer of staple fibre. There is a large potential demand for Japanese man-made fibres especially in the Far East, although here political factors often blur the economic considerations. Japanese manufacturers are confident that the present phase will pass quickly and that their efforts in boosting exports will meet with success. If so a considerable increase in elemental sulphur usage will follow. There is moreover a possibility that the viscose rayon industry may look to elemental sulphur as the raw material for its sulphuric acid requirements. A study is at present being made to determine whether this would significantly contribute to a reduction of the costs. Japanese sulphur producers are hopeful of raising their production to keep in step with the increased demands of the future. They are, however, conscious of the industry's dependence on the co-operation of customers and the continuation of the Government's import ban. Rising output of domestic recovered sulphur may be expected to erode the present price level of Japanese sulphur which is likely to come under heavier pressure should some consumers determine to avail themselves of some of the abundant world supply of cheap sulphur, in particular of Canadian recovered brimstone.

Company Reports

Jefferson Lake Sulphur Company

IN HIS MESSAGE to shareholders and employees for the year 1957 Mr. Eugene H. Walet, Jnr., President of the Jefferson Lake Sulphur Company paid particular attention to the future demand in relation to supplies of sulphur. Concerning the current situation and events during 1957 Mr. Walet strongly criticised the decision to reduce both domestic and export prices by $3 per ton and looked forward to an early increase to a more economic level.

Sales and Prices

Despite difficulties experienced in many industries due to the lower level of economic activity, particularly during the last quarter of 1957, Mr. Eugene H. Walet, Jnr., stated that the company's own sales of sulphur were, at 380,000 long tons, greater than in 1956 and included peak domestic sales which had increased by 84% during the year.

Unfortunately, the President stated, the full benefits of these increased sales could not be obtained due to several factors. The most important of which were the $3 reduction in price, increased operating costs and the charge of drilling costs on non-productive wells. The price cut which the Company made to remain competitive was in his opinion not justified, and he believed that the apparent current stabilization of prices meant that in the not too distant future there should be a return to higher prices. These, he said, are not only justifiable but necessary to maintain a sound sulphur industry for peacetime prosperity as well as national security. Mr. Walet later in his message emphasized this point by stating that to-day's sulphur price of $23.50 was an increase of only 30% over the 1937 price although operating costs had risen by over 100%.

Production and Development

Total production of sulphur from all the Company's sources was reported to have amounted to 443,800 long tons. This comprised 223,000 tons from Long Point Dome including 111,889 tons produced and 82,411 tons shipped for the account of Texas Gulf Sulphur Company, Clemens Dome 103,000 tons and Starks Dome 96,000 long tons. The remaining 21,800 tons was recovered from sour gas, 17,000 tons from the plants at Manderson, Wyoming and 4,800 tons from that at Peace River, British Columbia, where production began in early November. The completion and successful operation of the Peace River sulphur plant was of considerable interest and although it was only operating for two months the annual capacity is 150,000 tons, making it the largest of its kind in the world. Sulphur reserves of the Company in Canada were stated by the President to be 25,000,000 long tons present in the form of sour gas. These Canadian activities which during 1957 were developed by the Oil and Gas Division will be carried on in future by Jefferson Lake Petrochemicals of Canada Ltd., an independent subsidiary.

	1957	*1956*	*1955*	*1954*
Long Point Dome	223,000	246,000	250,000	249,200
Clemens Dome	103,000	115,000	124,000	96,100
Starks Dome	96,000	93,000	111,000	88,200
Manderson, Wyoming	17,000	19,000	15,000	—
Peace River, Canada	4,800	—	—	—
Total Long Tons	443,800	473,000	500,000	433,500

Particular reference was made by Mr. Walet to the successful expansion of the Oil and Gas Division's interests in Louisiana and Texas and continued drilling in the Gulf Coast area and Oklahoma. Further exploratory work in Canada had proved valuable. Recoverable reserves of oil and condensates amount to 4.6 million net barrels and gas reserves 570 billion cubic feet.

Other Company Activity

Expansion of facilities in the Petrochemicals Division (The Merichem Company)

were completed and according to the Company this gives a production capacity of approximately 200,000 gallons of crescylic acid per month. Additional research and development in this division will be continued.

Research and Development

The foremost matter on hand at present is development by Jefferson Lake of its Canadian interests. Plans for further finance and construction are being negotiated.

Of particular interest were appraisal reports by the Southwest Research Institute of San Antonio on the Bayou Sale Rotasorber Plant, the turbine submerged combustion water heater plant at Clemens Dome and the application of the rotasorber principle to the problem of removing hydrogen sulphide from sour natural gas by absorption.

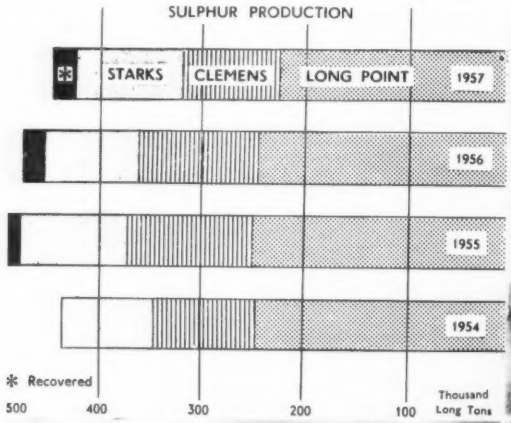
Financial

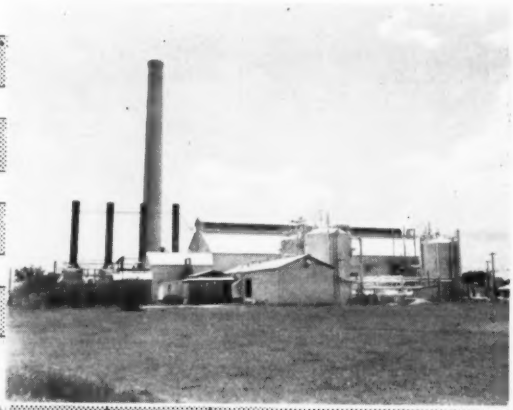
The most significant figure in the accounts is a capital expenditure of $7 million, the largest in the Company's history, which was occasioned by the growing sulphur recovery projects under the Company's Canadian development schemes.

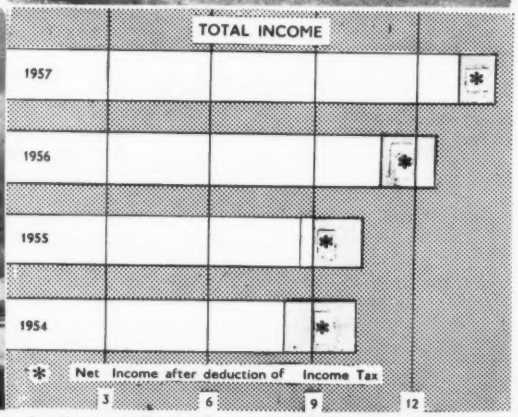
Despite increased gross sales company net earnings before tax declined by 64% from $2,154,060 in 1956 to $769,430. Due to a refund of Federal income tax of $478,694, net earnings after tax were $1,243,124 but this figure is still the lowest since 1950 and represents a drop of 22¼% from $1,607,786 in 1956.

The increase in total assets from $14,134,023 to $19,176,326 was largely accounted for by the Peace River plant, the Merichem Division and the Oil and Gas Division whilst Cash and Inventories showed a considerable decline.

Liabilities increased largely due to a rise in long term debt from $4,067,000 to $8,085,750, most of which was in the form of a 5% Promissory Note due in 1971 to the Prudential Insurance Company of America, indebtedness to whom is now $6,867,000.







Bottom left photograph, Clemens Dome, loading vat. Top right, power plant.

One exceptional item was the expenses in connection with the proposed offering of additional common shares which, the President stated, the Company had been compelled to withdraw.

Conclusion

Basing his statement on the fact that to-day's proven reserves of elemental sulphur have a shorter life than 25 years ago and that he estimated world consumption of sulphur in all forms by 1965 at 24 million tons, of which elemental will supply 15 million tons, Mr. Walet saw the future as favourable to producers. In his view the continued search for additional reserves of sulphur must go on. Substance is given to this by the Company's intensive programme of development of the Canadian projects for sulphur recovery and natural gas, and the supporting capital investments.

Duval Sulphur and Potash Company

THE REPORT of the Board of Directors, submitted by Mr. W. P. Morris, the President of the Company, states that increases in the volume of sales of both sulphur and potash resulted in an increase in net income for 1957, although there have been decreases in the sales prices of both products. Net income for the year was $3,109,729, an increase of $602,824 over 1956.

Finance

The stock offering, referred to in the 1956 Annual Report, was made to stockholders in March 1957, and Mr. Morris said that the 300,000 shares offered were fully subscribed. The statement of income and earned sulplus, contained in the annual report, showed that the Company's total sales (excluding freight and allowances, etc.) were $13.9 million, an increase of over $0.6 million compared with the figure for 1956, and after making provision for federal and state income taxes, net income for 1957 was $3,109,729, an increase of $597,823 over the previous year. Expenditure on non-productive exploratory research was $131,297 compared with $443,811 in 1956.

New Construction

In the report, Mr. Morris said that "work on the construction of copper and molybdenum mining and milling facilities on the Company's properties in Pima County, Arizona, was begun during 1957, and is proceeding on schedule. $6.2 million of an estimated total cost of $21 million was expended by the end of the year. The Company expects to place the mine and mill in operation during the first half of 1959."

Potash

The President reported that drilling operations were continued on the 395,000 acres in Saskatchewan, Canada, on which the Company holds Potash rights, and that approximately $367,000 was expended on these operations during 1957. He added that the Company is now evaluating the results of exploratory drilling on these lands, with a view to planning their future exploration or development.

Mr. G. F. Zoffman

Mr. W. P. Morris expressed the deep regret of the Board at the death on 5th June, 1957, of Mr. Zoffman, his predecessor as President of the Company. Mr. Zoffman became associated with the Company in 1929, and was elected its President the following year.

Summary

The Company's only source of sulphur is their Orchard dome, where production has fallen steadily during the last five years to a level of 153,000 tons in 1957. There is no indication that this trend may be reversed, and it seems likely that the Company will devote increasing attention to the mining and processing of potash and copper.

Stauffer Chemical Company

AT THE annual meeting of the Company held in San Francisco on March 26th, Mr. Christian de Guigne, Board chairman, expressed considerable confidence in the Company's future despite the slackness in the United States economy. This confidence is reflected in plans for expansion to be implemented during 1958, which amount to $14,000,000—approximately the same level as during 1957.

One of the largest consumers of sulphur in the U.S.A., the Company's sulphuric acid plants are based on Frasch and recovered

sulphur, H_2S and sludge acid from oil refineries. In 1957 four new plants were completed for the production of sulphuric acid, petrochemicals, titanium tetrachloride and boron trichloride. Additional to these new plants, existing units for the production of boric acid, zirconium tetrachloride, recovered sulphur and pebble lime were extended. A sulphuric acid regeneration plant at Hammond, Indiana, is scheduled to be completed this September, and two new plants for the production of Stauffer's insecticide "Trithion" and pelletized superphosphate have been brought on stream. Also a major facility for the production of hydrofluoric acid is being constructed at Louisville and should come on stream shortly.

The Company's special knowledge and basic position in such raw materials as boron, phosphate, sulphur, fluorine and chlorine, said Mr. de Guigne, offer an unusual opportunity for Stauffer. This is particularly so in a future marked by nuclear power and supersonic flight. Stauffer is giving special emphasis in its research programme to these fields.

Turning to the more immediate state of the economy the Board anticipated that business in 1958 would reflect the general trend. However, in Mr. de Guigne's opinion new and enlarged capacity should contribute to both sales and earnings, particularly in the Agricultural Chemicals Division.

Results for the first quarter of 1958, reflect the official forecast of the prospects for the year with earnings down by 11.5% due to lower operations and higher charges for depreciation. Agricultural chemicals on the other hand were substantially ahead of the 1957 returns, due particularly to large export shipments.

The confidence and far-sightedness shown by many large companies in the United States, amongst whom the Stauffer Chemical Company is prominent, is one of the most effective weapons against recession and as such is of importance to the whole chemical field.

The Tharsis Sulphur and Copper Company Limited

THE REPORT and Accounts for the year 1957 were submitted at the Annual General Meeting of the Company on the 14th May, 1958. In his speech, Mr. W. P. Rutherford, Chairman and Managing Director, commented upon the difficulties being experienced in the sulphur industry at present, but drew attention to the company's strength which resulted from the policy of modernisation and development pursued in recent years.

Accounts

Trading profit for the year 1957 declined by just over 10% to £635,558. Net profit at £220,234 was 2% greater than in 1956; mainly on account of a lesser tax liability. Transfers to general reserve were again £150,000 and the dividend was maintained at 12½%, equal to 5/- per share payable less Income Tax. Capital expenditure in 1957 on rolling stock and mining plant was £419,948 and Mr. Rutherford pointed out that sums spent on capital additions since the war have been very high and have been provided almost wholly from the company's own resources.

Although Spanish tax on profits and dividends has been a heavy charge against the company's profits, considerable allowances for such charges have been received in the form of Unilateral Relief against British tax liabilities. Consideration is still being given by Her Majesty's Board of Inland Revenue to the company's qualifications as an Overseas Trade Corporation, but the Chairman stated that with increasing taxation in Spain it might be to the company's greater advantage to be excluded.

Mines

Due to lower exports and running down stocks, mining operations, especially at Calañas and Sierra Bullones, the company's main producing mines, were at a lower rate than in 1956 but all departments worked satisfactorily. Surplus labour due to lesser production activity was being successfully employed in preparatory work at the Centre Lode scheme. At North Lode major items of plant have been installed and a small amount of pyrites has been drawn from this opencast mine for cupreous pyrites shipments. When completed an underground road between North Lode and the Sierra Bullones mines will permit exploration of North Lode at depth and enable the output of both mines to be handled in the same plant. After

careful investigation mining operations have commenced on Centre Lode 3rd Floor where the scheme is for a small opencast working, which promises favourable operating costs.

The life of the interesting and profitable cyanide mill for the extraction of gold and silver from gossans, which has been operating for 23 years, is being prolonged by using gossans from old overburden dumps.

Callañas mine. Tharsis village middle distance.

Turning to ancillary developments the Chairman states that at Corrales, close to the shipping pier, the crushing plant has been modified to allow a more finely-crushed product being supplied. Covered storage has also been erected to cope with special classes and the transporter depot near the sea has been enlarged for the same reason and in view of the intention to export old stocks of calcined residues which at present are lying at the mines. The railway is now completely relaid with 70lb. and 90lb. rails and operating smoothly. Oil-fired locomotives have shown a considerable reduction in operating costs and trials with 42-ton rail cars continue.

Pyrites market

In 1957 the company shipped 692,837 tons, a reduction of 40,500 tons (5½%) compared with 1956 deliveries. Despite current difficulties in the pyrites trade the Chairman looked to the future with confidence : the company, he said, had a first-class property with plant that is modern and efficient and capable of sustaining much greater activity than the market could at present accommodate. In export markets pyrites producers had lowered their prices by 22% since 1956. Pyrites sales to the Spanish chemical trade, the company's largest market, are controlled at prices that do not cover all costs. By increasing the controlled price this industry so important to Spain would be protected and placed in an improved competitive position. It was necessary, the Chairman said, to keep pyrites competitive with sulphur from other sources, not only with Frasch sulphur from the United States and Mexico, but also the growing of supplies from the Lacq field. In this connection he expressed the view that should sulphur prices decline the high content iron ore residues of pyrites, constituting an important rebate to the buyer, meant that pyrites would be less affected than elemental sulphur. Finally he emphasised that in the determination of prices the rate of exchange constituted an important factor which the Government could use as a further means of protecting the Spanish pyrites industry. The company's mining programme is aimed at increasing production of cupreous pyrites, the residues from which are treated by Duisburger Kupferhütte in Germany, part of the resultant copper is returned to Spain and this provides the company with an extra source of revenue.

In conclusion, Mr. Rutherford stated that, although demand for sulphur would undoubtedly continue to increase, the potential production of sulphur in all forms was at present greater than demand. Because of this " it would appear that a gradual readjustment of European markets by transatlantic sulphur producers will be necessary."

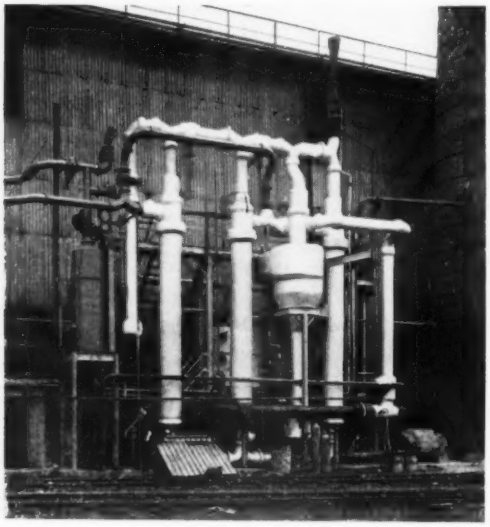
Current Events

UNITED KINGDOM

New Coal Gas Desulphurisation and Sulphur Recovery Process

After ten years of experiments and pilot plant trials, *Appleby-Frodingham Steel Company*, a branch of the United Steel Companies Ltd., have developed an entirely new process to desulphurise coal gas and recover the sulphur content of the extracted H_2S in the form of sulphuric acid. The plant and process is claimed to incorporate major advances on any existing similar method and, due for completion by mid-1959, the first full-scale plant is now being installed at Appleby-Frodingham.

A variety of processes, both wet and dry, are at present in use for the removal of hydrogen sulphide from coal gas. In the case



Appleby-Frodingham Pilot Plant

of steel works this is intended to ensure the quality of the end-product, and for town gas works to met statutory obligations on sulphur content of gas; the Appleby-Frodingham process should find applications in both sectors of the coal gas industry and also the chemical and petroleum industries.

The new plant consists basically of three fluidised beds. The first two contain a catalyst of Northampton ironstone and fluidised by the coal gas are maintained at temperatures of 350°C and 400°C respectively. As the coal gas containing H_2S is pumped through the beds a reaction takes place, the sulphur and catalyst forming FeS. The FeS is then blown into the third fluidised bed which is sustained by air where it burns at 750°C to give SO_2 and Fe_2O_3. The Fe_2O_3 is then re-cycled and an acid gas containing 12% SO_2 passes straight to the acid plant. Use of fluidised beds reduces the amount of purification mass by four-fifths, compared with that involved in spent oxide boxes. It is reported that the catalyst has been re-cycled over one hundred times without loss of effect, and its cost is said to be only two-thirds that of the pelletized spent oxide. The plant for preparing the catalyst is six times larger than is at present needed, to allow for expansion of operations.

Both hydrogen sulphide and organic sulphur can be removed to very low levels, and the heat requirements of the plant are met by combustion of the sulphur, which once started is exothermic. Employment of hot gas makes the process much faster than conventional iron oxide boxes or purification towers. In compactness and capital cost the process is said to compare very favourably with existing methods, while the entire operation of the full-scale plant is capable of being handled by two men per shift.

A pilot plant has been in successful operation for two years, purifying up to three million cu. ft. of coke oven gas per day. The full scale plant, when completed, will deal with 32 million cu. ft. of gas per day.

Appleby-Frodingham have appointed two licensees to build plants based on this process. They are Henry Balfour & Company Ltd., of Leven, Fife, and W. J. Fraser & Company Ltd., of Romford, Essex. The unit at present under construction at the Appleby-Frodingham works is being built by W. J. Fraser & Co. Ltd.

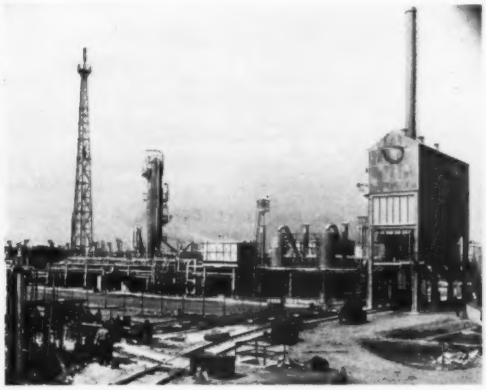
British Petroleum Co.—New Sulphur Recovery Plants

Commissioned early in May, the new sulphur recovery unit at the *British Petroleum Company's* Isle of Grain, Kent, refinery is currently working at about 60% of rated

capacity. The unit was designed by Simon-Carves Ltd., of Cheadle Heath, Stockport, and is capable of producing 45 tons per day high purity elemental sulphur, and when in full operation will be supplied by H_2S from the catalytic cracker and two hydrofiners.

At present only one hydrofiner has been completed under the major expansion scheme of this refinery and the second hydrofiner is expected to be in operation during the autumn of this year. These two desulphuriser units were designed by the Kellogg International Corporation.

The design of the sulphur recovery unit is based on a modified Claus kiln with two stage conversion and after-burning equipment. Steam generated in the main waste heat boiler is used in the refinery, while that produced in the gas coolers is used for steam jacketing.



British Petroleum Co. General view of sulphur recovery plant at the Isle of Grain refinery prior to completion.

The sulphur output may be disposed of either in flake form produced in Mitchell drum flakes, or as molten sulphur despatched in bulk road tankers. A small proportion of the sulphur will be used to produce make-up acid in the Simon-Carves acid recovery plant. This latter plant will be fed with spent acid from the sulphuric acid alkylation plant and will produce 35 tons per day of 98% acid. It is estimated that initially half the total of sulphur produced will be available for the domestic market.

Simon-Carves Ltd.—Plant Construction Progress

The Spring review of activities of the Chemical Plant Department of *Simon-Carves Ltd.*, reports an intensive building programme which includes the completion of five sulphuric acid plants while three are under construction.

Two major brimstone burning installations have been completed in the U.K., one for Messrs. Fisons Limited at Immingham and the other for Laporte Titanium Ltd. at Stallingborough, with daily capacities of 140 tons and 175 tons respectively. The sulphur recovery plant at the British Petroleum's Isle of Grain refinery was commissioned in May and work is well advanced on the sludge acid plant.

The completion for Kiwi Fertilizers at Morrinsville of the 110-ton per day contact sulphuric acid plant based on the use of brimstone, forms an important part of the expansion phase of New Zealand's fertilizer industry; two further plants of similar capacity and design are under construction by Simon-Carves for the Bay of Plenty Fertilizer Company at Tauranga and The Southland Co-operative Phosphate Company at Awarua.

In Australia the sulphuric acid plant for Mary Kathleen Uranium Mines Ltd. has been completed and with its capacity of 110 tons per day (100% H_2SO_4) is supplying the needs of the uranium processing mills. Work is progressing at Geelong on the important 100 tons per day sulphuric acid plant at the Shell oil refinery based on H_2S in refinery gas. Other plants which have been completed are the 184 tons per day plant at Rhodia for African Explosives and Chemical Industries (Rhodesia) and the oleum and pot concentration plant for Imperial Chemical Industries at Gomia, India.

Contracts for acid plants are in hand for Cowburn & Cowpar Ltd., of Trafford Park, Manchester, and also DuPont de S.A. de C.V. in Mexico. The plant at Trafford Park will have a design capacity of 50 tons of (100% H_2SO_4) in the form of 94% acid and will incorporate the latest techniques in sulphur burning and waste heat recovery. For the Industrial Cellulose Corporation and the Umfolizi Co-operative Sugar Planters, both in the Union of South Africa, two sulphur dioxide plants have been ordered.

Other activities of the Group include the start-up of the wet contact acid plant for the North Thames Gas Board at Beckton by Hunt-

ington, Heberlein & Company Limited. This company has also recently completed all work on the Herreshoff roaster for the Rhodia acid plant at Salisbury and is now engaged on the extension and modification to permit the alternative use of pyrites and brimstone at Norsk Spraengstofindustri's sulphuric acid plant at Oslo.

AUSTRALIA

Sulphur Self-Sufficiency

In the March issue of Sulphur, on Page 13, it was stated that it is the official aim to achieve at least 60% sulphur self-sufficiency in the Australian sulphuric acid industry. The aim was, in fact, to achieve 65% conversion to indigenous materials by 1956, this target being essentially a short-term objective. The present aim is to have acid plants, particularly new acid plants, based on local materials wherever practicable.

CANADA

Natural Gas Developments

Intensive exploration and heavy investment in Canada's rapidly expanding oil and gas industry is resulting in continuous discoveries or plans for development of gas reserves. Recently a project costing $60 million has been announced for the Windfall area between Sturgeon Lake and the Pembina oilfields in Alberta. Companies concerned include Canadian Fina Oil, Hudson's Bay Oil and Gas and Pan American Oil. The operating group estimate probable and possible reserves in the area at 1,600 million cubic feet of gas plus reserves of natural gasoline and other gases. Plans announced so far envisage plant to recover sulphur and liquid hydrocarbons.

Canadian Husky Oil Company, in participation with California Standard Oil, Phillips Petroleum and British American Oil, have reported the completion of a gas well in the Dick Lake field of Alberta. This well with a potential of 288 million cubic feet daily may prove to be the most productive yet drilled in Canada. Hudson's Bay Oil and Gas who are participating in the Windfall project have, in co-operation with Canadian Delhi Oil, staked six wells in the Cessford gas area 100 miles east of Calgary, plans include a $3.5 million gas refrigeration plant.

Plans for the development of gas pipeline systems, vital to the utilization of the reserves, are also going ahead. North-western Utilities and Canadian Western Natural Gas have recently announced schemes to increase gas supplies to Edmonton and Calgary respectively. Gas for Edmonton will be piped 45 miles from the Pembina fields whilst Calgary's supplies are to be met by new pipe lines from the Carbon and Bow Island fields. The largest project during 1958 will be the $11 million 145 mile line connecting the main pipe line with the Pincher Creek gas field in South Western Alberta. British American Oil, who have a large holding in Pincher Creek, are successfully operating the gas cleaning and sulphur recovery plant, but full exploitation of these large gas reserves at the Company's disposal is dependent upon completion of the Trans-Canadian pipe line system. Good progress is reported by Alberta Gas Trunk Line which will serve the Cessford Field.

These discoveries of large reserves of Canadian natural gas have tended to obscure the slow rate of effective market development. The effect of this upon the fortunes of operating companies is obvious particularly in view of the large amounts of capital involved. Shell Oil state that its Jumping Pound field had a capital and income deficit of $12.3 million by the end of 1957. Yet this field is in a better position than most in that it has actually been supplying gas for several years. This point was also made plain by Mr. E. D. Loughney, Senior Vice-President of British American Oil.

Mr. Loughney stated that Canadian natural gas producers will be forced to cut back on their exploration and development operations if adequate markets do not appear in the near future. He then stated that if a cut back became operative it would become increasingly difficult to procure gas at a price competitive with other fuels. Transmission companies would have to take their supplies from small "sweet" gas fields. These facts stated by Mr. Loughney would obviously have an effect on by-product industries based on natural gas including sulphur recovery. Economic implications of such a development would be very considerable and although existing projects are unlikely to be affected future plans might have to be revised.

Mr. Loughney said that the immediate problem was to obtain an economic return on the large investments made to furnish sufficient funds to carry on further utilization of Canada's gas reserves. Total expenditures

since 1947 have amounted to $3,200 million and a substantial portion of this has been spent on finding gas, yet gas production has provided only 3.4% of total production income and expenditure has exceeded income every year. Mr. Loughney urged a policy which would permit the immediate export of gas surplus to Canada's foreseeable needs.

This need for an export market has been emphasised by recent discoveries in the foothills region of Alberta. These discoveries are outside the orbit of the Trans-Canada pipe line system and their development depends on an export outlet. Two long distance pipe lines have been proposed to the markets in the United States but the applications have not yet been granted.

In contrast to the attitude of the companies the Provincial and Dominion Governments have questioned the wisdom of a gas export policy before domestic requirements are assured. The Borden Commission is now hearing evidence on Canada's energy requirements and the Federal Government is unlikely to embark on a definite policy regarding exports required by the industry until the Commission reports some time in 1959.

The main contribution to current sulphur recovery production in Canada is being provided by the recently formed Jefferson Lake Petrochemicals of Canada Limited, a subsidiary of the Jefferson Lake Sulphur Company, which is to retain approximately 69% of the new shares capital. Initial activities of this Company consist of sulphur production from purchases of H_2S at the existing plant at Peace River, British Columbia, and developments are foreseen at Savannah Creek and east of Calgary for the production of sulphur and commercial pipe line gas. The location of the existing plant places the Company in a favourable position to supply the sulphur requirements of the markets of Western Canada. The current rate of sulphur production is approximately 100,000 tons a year. Texas Gulf Sulphur Company, the largest Frasch producer, has also begun the construction of its sulphur recovery plant in the Okotoks gas field of Alberta, where operations are planned in conjunction with the Devon Palmer Oils Ltd. Capacity of this plant which was originally planned to begin operating in late 1958, will be 360 tons of high purity sulphur a day.

Production of recovered sulphur in Canada during 1957 was approximately 100,000 tons and a conservative estimate of the current annual rate of production places it at 250,000 tons.

SOUTH AFRICA

New Source of Sulphur

The Standard-Vacuum Refining Co., of South Africa (Pty.) Ltd., the only major South African oil refinery, has commenced a £5 million expansion scheme at the oil refinery at Wentworth, near Durban. Amongst new units is a sulphur recovery plant which is being installed at a cost of about £300,000. It will have a capacity of 20 tons per day high purity brimstone, and it is expected to be in operation by the middle of 1959.

New Pyrites Acid Plant

Simon-Carves Limited, of Cheadle Heath, Stockport, announce that their subsidiary, Simon-Carves (Africa) (Pty) Ltd., of Johannesburg, has received an order for a pyrites-burning sulphuric acid plant to produce 120 short tons of acid per day. A £400,000 project, the plant will be built for the *Harmony Gold Mining Company Ltd.*, in the Orange Free State. Like Blyvooruitzicht Gold Mining Company, for whom Simon-Carves Limited built a similar plant with a capacity of 134 tons of sulphuric acid per day in 1956, it is one of the constituent companies of Central Mining Finance Limited. The new acid plant will bring the total number supplying acid for uranium oxide extraction of gold ore slimes to nine and their aggregate daily capacity to about 1,650 tons (100% H_2SO_4).

UNITED STATES

Grand Isle Project

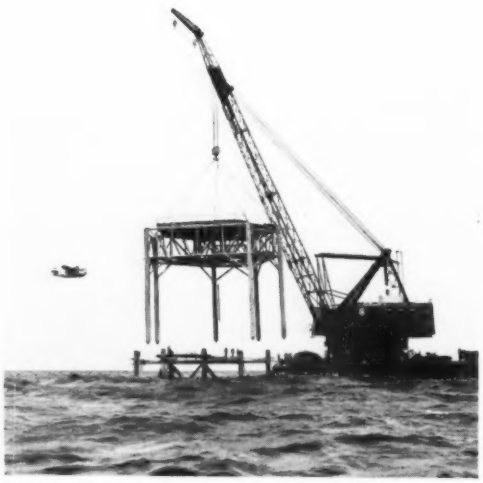
The Grand Isle sulphur dome is seven miles off the coast of Louisiana, one of the most important sulphur discoveries in recent years. On June 20th the *Freeport Sulphur Company* who plan to exploit the deposit started work on the steel structure which is due to be completed in 1960 and will house drilling, power, water and ancillary installations required to sustain the Frasch process.

Operation of the world's first off-shore sulphur mining plant has involved specialist problems, particularly in drilling. The structure from which operations will take place is a Y-shaped structure nearly a mile long and

rising 60 feet above the water and is the principal part of Freeport's $30,000,000 project.

The first of the 17 huge templates which will serve as a guide for the piles has been placed into position in 50 feet of water. These, in addition to providing a pattern spacer and guide for pile driving, serve as a means of stiffening the underwater portion against hurricane force winds and waves.

Largest of the installations to be erected is the heating plant, shops and warehouse unit. The plant will use 13,000,000 cubic feet of gas a day in heating 5,000,000 gallons of sea water for injection into the underground formation. It will also produce the electric power to operate drilling rigs and other equipment.



Freeport Sulphur Co. The 172 ton deck section being placed in position by a giant floating crane at the Grand Isle project.

Two drilling platform units at the ends of the Y arms will accommodate the derricks from which directional wells will be drilled to the sulphur 2,000 feet below. Due to being restricted in position by the limits of the "island" the method of drilling must incorporate considerable flexibility and much planning has gone into these units, which are probably the most versatile in existence. A third drilling platform will be some distance from the main platform.

The whole structure accommodating the complex equipment and living quarters has been described as "The world's largest steel island."

Sulphur Export Corporation

On May 9th it was announced that Texas Gulf Sulphur and Freeport Sulphur Companies agreed to reform the *Sulphur Export Corporation* which, after 30 years' successful trading, had been dissolved in 1952. Since then the two founder companies have invited Jefferson Lake Sulphur and Duval Sulphur & Potash Companies to join in the enterprise and this they accepted so that now on all matters appertaining to exports, Sulexco speaks with one voice for the entire United States Frasch sulphur industry. The advantages to the producers are evident, in that the number of competitive bids is reduced and the price is steadied. Sulexco's policy is to sell in the various world markets through one of the individual producer's established local agents or distributors, although where local conditions may demand it two or more agents will deal with the Company's affairs. Thus for example in the United Kingdom non-acid sulphur sales will continue to be effected through F. W. Berk & Co., Chance & Hunt Ltd., and Tar Residuals Ltd.

Chairman of the Corporation is Mr. C. T. Hill, Mr. Peter Black is President, and the Board of Directors include Mr. C. O. Stephens, President of Texas Gulf Sulphur Company, and Mr. C. A. Wight, Chairman of the Executive Committee of the Freeport Sulphur Company, and one senior executive each of Jefferson Lake and Duval Sulphur & Potash Companies. The Corporation's formation and activities are governed by the Webb-Pomerene Act, which permits United States' companies to form a jointly-owned subsidiary to attend to their overseas sales.

Summing up the scope of the Company, Mr. Black says:—"The advent of the Sulphur Export Corporation should be of considerable advantage to our customers in that they will have the advantage of the combined reserve position of the member producers together with the advantageous freight position which will result from combined shipments to all parts of the world and our being able to load at either Port Sulphur or Galveston. I may say that we intend to sell competitively and to

do our utmost to maintain and enlarge the world export position of the United States' sulphur industry."

SPAIN

Pyrites Acid Plant Project

Construction of the 110,000 tons per annum ammonium sulphate plant which is to be erected at the new 70,000 barrels per day refinery of the *Compania Espanola de Petroleos, S.A.*, near Las Palmas, will be completed in June, 1960.

Contrary to earlier reports* that hydrogen sulphide recovered from oil refinery gases will be used for sulphuric acid manufacture, this will be based on the use of pyrites. The 250 t.p.d. 100% H_2SO_4 acid plant is being designed by Chemiebau Dr. Zieren. Supplies of pyrites will originate from the Huelva district and probably be charged at the controlled low domestic price which at present allows pyrites being landed at Teneriffe at Ptas. 360 per metric ton C. & F.

Owing to present market conditions the projected installation of a hydrofining unit has been postponed indefinitely. Consequently the anticipated crude throughput of 50,000 barrels per day, even at maximum recovery of the sulphur content of kerosene and gas oil distillates would supply only 20% of the acid plant's sulphur requirements. In these circumstances the installation of sulphur recovery plant was not considered attractive.

MEXICO

Fertilizer Projects

Two major factors promoting increased fertilizer demand in Mexico are the Government's drive to increase agricultural productivity and the opening up of large new areas by irrigation. Existing projects will, it is estimated, bring an additional million acres into cultivation in the near future. As part of this programme domestic fertilizer production is receiving considerable attention. Developments by three major Mexican companies based on domestic supplies of sulphur, oil and natural gas will do much to meet demand.

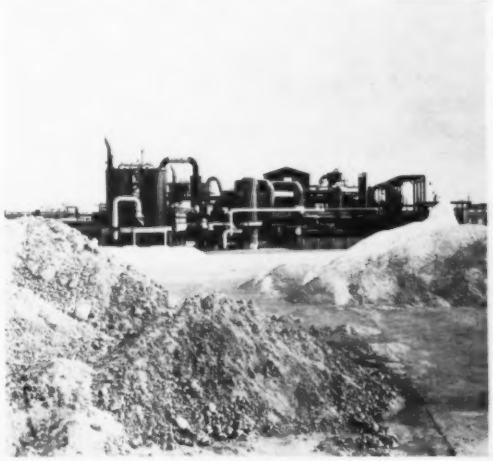
Two plants of *Guanos y Fertilizantes de Mexico, S.A.*, in Coatzacoalcos and Ciudad Madero will, according to reports, produce 150 tons of triple superphosphate and 100 tons of single superphosphate per day respectively, coming on-stream by the end of 1958. Both these plants will probably be based on recovered sulphur supplied by PEMEX. The same company's ammonium sulphate plant at Cuantitlan is to double capacity to 150,000 tons a year.

Fertilizantes de Monclova, S.A., expect by the autumn to be producing 100 tons a day of ammonia at their new synthesis plant. The bulk of the next five years' requirements of nitrogenous fertilizers is expected to be provided by a new company, *Fertilizantes de Bajio, S.A.*, which is being formed by Guanos y Fertilizantes and two financial institutions and which will base its operations on oil refinery gases from Salamanca. The plant which is to cost £2.5 million will make 35,000 tons of anhydrous ammonia to be used in producing 32,000 tons of nitric acid, 40,000 tons of ammonium nitrate and 17,500 tons of urea. It is of interest to note that the remaining 7,000 tons of anhydrous ammonia will be used for direct fertilizer application in keeping with the growing practice in the United States. It is, however, significant that none of this principal output of nitrogenous fertilizers will require sulphur in its manufacture.

FRANCE

St. Gobain—New Sulphuric Acid Plants

In the spring of this year the commencement of operation of the new sulphuric acid plant of *St. Gobain, Chauny and Cirey* at Le Havre, marked an important stage of the Company's modernisation and expansion programme. The



St. Gobain. General view of the recently completed plant at Le Havre.

* "Sulphur" Number 19, page 37

plant, a 240 tons (100 H_2SO_4) contact installation is to be supplied with recovered brimstone from the Lacq natural gas cleaning plant but there is also provision for using H_2S piped from a nearby oil refinery. The Company's Oseraie (Vaucluse) sulphuric acid plant, has recently been modernised. This source of acid supply will be augmented by production from a new plant now under construction at Saint-Fons (Rhône); due to be completed this autumn it will be one of the largest pyrites burning plants to be built in Europe and will have a capacity of 330 tons per day (100% H_2SO_4). Fluidized bed roasters will be fed with pyrites concentrates from St. Gobain's own mines. The plant will incorporate new techniques in heat recovery and in the convertor section. It is designed to meet the Company's rapidly rising sulphuric acid needs for fertilizer manufacture.

POLAND

Sulphur mining

For the current year 250 million Zloty have been allocated for the development of the sulphur mines in the Vistula basin. Much of this allocation is to be spent on further developments at Piaseczno where the original scheme was for a pilot plant raising approximately 100,000 tons of ore a year. Important changes have now been made in plans for construction in order to speed this up and also to increase the rate of extraction. It is announced that, when the mine is in full production, output will be 1.9 million tons of ore annually instead of 750,000 tons. The planned tonnage of pure sulphur to be extracted from the Piaseczno crude ore output will similarly increase from 150,000 tons to 350,000 tons annually, whilst the envisaged cost of production should decrease 20%. In order to help achieving this rapid development at Piaseczno, construction of a second sulphur mine at Machow has been slowed down, enabling more investment to be concentrated on Piaseczno. When eventually the mines at Machow are also brought into full operation, they are intended to yield 3 million tons per annum of ore, which will be concentrated and refined into 600,000 tons brimstone. The recent discovery of yet another deposit near Piaseczno, said to contain an average of 60% sulphur ore, may later cause a re-allocation of priorities.

In the meantime, the project of the processing plant near Tarnobrzeg, on which the first phase of the programme hinges, is gradually taking shape; its initial design capacity is reported as 700,000 tons of ore per year, and more facilities may have to be constructed in order to deal with the eventual ore output of the Piaseczno mine. Construction work will begin this year and should be completed in 1961. The construction is also being started in 1958 of integrated sulphuric acid plant, which it is estimated, will produce 100,000 tons of acid a year by the end of 1960 and over 600,000 tons a year when in full operation. The refining of sulphur ore concentrates for the time being is to be carried out at Hirschberg in Upper Silesia, where a refining plant has recently come on stream. Shortage of skilled manpower is, according to an official report, causing some delay, but with the support which the Piaseczno sulphur combine receives from the authorities and from the Minister of Chemical Industry this setback is likely to be quickly remedied.

The forceful pursuit of the project is prompted by rising sulphur needs in Poland and neighbouring East European countries. In Poland the project has been designated as a necessary basis for the growing chemical industry, which in 1958 is to expand overall by 14%, including such individual targets as sulphuric acid +11.5%, nitrogenous fertilizers +23.5% and phosphatic fertilizers +19%. The magnitude of the Polish sulphur project and the concurrent development projects of native sulphur ores, pyrites and recovered brimstone in Russia, the Ukraine, Roumania and Bulgaria may be expected to give rise to a sulphur surplus and a disposal problem in Eastern Europe. At present construction and operation is causing the most concern, and in this respect Western experience in sulphur matters could make a useful contribution.

EGYPT

Fertilizer Plant Project

Within the framework of her aid programme the U.S.S.R. proposes to assist Egypt in building and equipping a triple superphosphate fertilizer plant. Depending on the method to be adopted the plant will be sited at Suez—wet phosphoric acid—or at Aswan—thermal phosphorus. Full details are the subject of current talks, but it is already reported that the plant will use annually 430,000 tons phosphate rock, and (sic) produce 25,000-50,000 tons

triple superphosphate. With regard to the possibility of wet phosphoric acid production it is relevant to note that Egypt at present bases her entire sulphuric acid production on imported pyrites, since domestic recovered sulphur output is committed for non-acid uses. The development and exploitation of a sizeable rich sulphur ore deposit on the Sinai peninsula is projected and this is intended to yield enough refined sulphur to make Egypt self-sufficient and at the same time boost her uses of sulphur amongst which the manufacture of fertilizers is prominent.

IRAQ

Sulphur from Natural Gas at Kirkuk

Three hundred tons of elemental sulphur a day will be recovered from natural gas at a plant to be built at the Kirkuk oil fields for the *Iraq Development Board*.

After stiff competition between American, British, West German and Italian firms, a contract to build the plant has been awarded to the American firm of Ralph M. Parsons and Co., of Los Angeles, California. The Iraq Development Board decided in favour of Parsons on an unanimous recommendation of three experts whom they had engaged to study the tenders submitted by the competing firms. The plant is to be completed within 25 months, and will cost £7 million.

Eighty million cu. ft. of natural gas a day, which at present run to waste, will be used by the new plant. In addition to sulphur, it will produce 300,000 gallons of propane, butane and gasoline, and 50 million cu. ft. of sweet gas a day. The sweet natural gas will be piped from Kirkuk to Baghdad to meet industrial fuel requirements through the gas pipe lines which are now being planned. The plant will also supply sweet gas to the Dibis power station.

Some of the sulphur recovered will be transported to Basrah by rail and exported, but large quantities are to be retained for use in the fertilizer and rayon industries which Iraq intends to develop.

CHINA

Fertilizers and Sulphur

In a country where the population is increasing by 13 million a year the problem of maintaining adequate food supplies is always pressing. Chinese authorities have decided that the most efficient way of tackling this is by the increased use of fertilizers. It is to meet this need that the Second Five Year plan is placing so much emphasis on fertilizer production.

By 1949 the ravages of war had virtually destroyed the small Chinese fertilizer industry and a new programme had to be devised. In 1957 production of all types of chemical fertilizers reached 800,000 tons, however, the authorities admit that this is only a fraction of the country's requirements. A large building plan has been put into operation to meet these needs, and envisages a production of 5 to 7 million tons by 1962. During 1958 alone new plants should add an annual output of 1,600,000 tons of nitrogenous and 800,000 tons of phosphatic fertilizers. The size of the problem has necessitated a wide approach and it is of interest to note that, apart from the national programme of large factory units, a simplified scheme for local production is to be put into operation. This envisages the manufacture of ammonium bicarbonate on a county basis with a standard type of plant employing manual labour instead of power. As far as possible local materials will be used in construction, and output should reach 8,000 tons annually for each plant. It is suggested by the authorities that this project will add 8 million tons to total capacity during the next few years.

Although not all the new fertilizer production will require sulphuric acid, greatly increased capacity will be needed, and developments in acid production are being co-ordinated with the fertilizer programme. China is reported to be planning an annual production of 4 million tons of sulphuric acid by 1962, compared with existing capacity of approximately 450,000 tons and production of 280-300,000 tons. Allowing for much of the increased nitrogen production not being based on sulphuric acid and the ratio between nitrogenous and phosphatic fertilizers remaining in favour of nitrogen, 4 million tons of sulphuric acid, or even the more likely level of 3 million tons, would seem to leave a substantial margin for activities other than fertilizer manufacture. Little information is available on details of recent acid plant construction, but many of the units associated with the new fertilizer plants must be large. New capacity added so far in 1958 amounts to 40,000 tons, which is probably at Tientsin. At Harbin, Manchuria, a 200,000 tons per annum nitrogenous fertilizer plant

is being constructed, other projects in the area include several plants for the manufacture of sulphuric acid, at present all the sulphuric acid needed by the fertilizer plants in the district has to be shipped from Nanking.

Due to the large increase in fertilizer production planned this year, requirements of sulphur may rise by as much as 150,000-200,000 tons by 1959. China appears to have a surplus and large reserves of sulphur in the form of native sulphur ore and pyrites, and it is evident that in the future these reserves will be more fully exploited. Construction of a sulphur plant with an annual capacity of 50,000 tons has started in the Chilien mountains in Kansu Province. These works, which are scheduled to be completed by the end of 1958, will provide a valuable addition to supplies. As yet there is no evidence that the recovery of sulphur from industrial gases, notably oil refineries, is playing a part in China's sulphur industry.

There appears to be no likelihood that China's ambitious plans for the chemical industry, particularly fertilizers and sulphuric acid, will be handicapped by a shortage of sulphur. Indigenous supplies should prove more than sufficient to the country's requirements and, indeed, it is probable that China will remain a net exporter of sulphur.

JAPAN

New Pyrites Deposit

The Matsuo Mining Company, Japan's largest individual pyrites and sulphur ore producer, reports the discovery of a new deposit of iron pyrites. Estimated at several million tons, the new reserves are situated near Matsuo's existing ore bodies in Northern Honshu. The sulphur content of the ore is stated to be quite high and adequate for the manufacture of sulphuric acid, whilst the residue is considered suitable for supply to blast furnaces.

NORTH KOREA

Expansion of Fertilizer Output

A five-year plan upon which North Korea has recently embarked pays particular attention to the expansion of output of fertilizers and other agricultural chemicals. This feature is typical of the provisions of the chemical industry as a whole which is scheduled to develop at a greater rate than any other sector of the national economy, including iron and steel.

In March the Chairman of the State Planning Commission announced the 1961 output target which amounted to 630,000 tons chemical fertilizers—nitrogenous and phosphatic—which is $3\frac{1}{4}$ times greater than the current total of 197,000 tons. It is significant that prior to the Korean War this was 394,000 tons, the decline being attributed to war devastation of production units.

The planned increase by 1961 is to be the result of both greater utilization of existing capacity and construction of new plant. In addition to an ammonium nitrate plant with a 135,000 ton capacity which is to begin operation this summer, a 30,000 tons per annum sulphuric acid plant is due to come on stream before the end of the year and construction is to start on a superphosphate factory capable of producing 100,000 tons annually.

The rapid development of the chemical industry, particularly of fertilizers, has necessitated increased supplies of sulphur and sulphuric acid. Recent surveys south of Hangyong province are reported to have disclosed large deposits of iron pyrite which are to be exploited although no date has been mentioned and this may be a long-term project. The proposal includes a washing centre with a 12,000ton capacity. At Mandok the iron pyrite mine has been restored and expanded to three times its pre-Korean War capacity and the washing plant is now reported to have an annual capacity of 500,000 tons crude ore. The mines supplies the Hungnam fertilizer factory.

The development plans lean heavily on technical and financial assistance which is to be given by the U.S.S.R. and China.

U.S.S.R.

Expansion of Sulphur Industries

U.S.S.R. maintains its position as "pacemaker" for the communist world in industrial and agricultural achievement. Progress in the development of basic industries has been very considerable and, according to a recent statement by Mr. Krushchev, will continue. During the next eight years it is reported that more than 100,000 million roubles will be allocated for building and reconstructing 257 chemical enterprises within the Soviet Union. As a measure of this programme, production of synthetic fibres is to rise 460%, plastics and synthetic resins 800% and synthetic rubber 340% by 1965.

As new territories are opened up for development, although this programme to-date has not fulfilled expectations, the demand for fertilizers records a steady growth. Production of fertilizers in U.S.S.R. is expanding to meet this demand and is reported to have reached an annual rate of 12,400,000 tons (336% above the 1940 level). Output in the first quarter of 1958 was 7% higher than the 2,897,000 tons for the same period of 1957 and, it is stated, more than fulfilled the production target. Based upon large deposits of phosphate and potassium ores supplemented with sources of nitrates, natural gas, oil and sulphur many new fertilizer projects are planned.

The Voskressensk combine, claimed to be the world's largest phosphate fertilizer factory, is to double output by 1959. In the Stavropol region several fertilizer factories are being built including a large nitrogenous plant and by-products from the new Stalingrad synthetic rubber industry based on natural gas, will be used to manufacture liquid ammonia for fertilizer production. Odessa has similar plans for employing by-products of its oil processing industry. In Central Asia, particularly the Bukhara area, developments of a mineral fertilizer industry is being encouraged and, resulting from criticism of current wasteful practices, use will be made of copper smelter gases and local deposits of phophorites, suitable for the development of a fertilizer industry based on indigenous supplies of gypsum, nitrate and potassium. At the other end of the Soviet Union local raw materials are also to be used in fertilizer production including volcanic sulphur from the Kurile islands and natural gas in Azerbaijan.

Soviet production of sulphuric acid is being developed as a basic part of the chemical industry programme. Production since 1957 has been running 5% greater at an annual rate of 4,800,000 tons, a rise of over 250% since 1940. Whilst this increase is considerable it is evident, in view of developments in consuming industries, that production of acid will have to rise at a higher rate to achieve the planned seven million tons by 1960.

In order to achieve this high rate of increase, supplies of sulphurous raw materials must be assured. At present acid production is mainly based on pyrites (79%) and it is probable that this source will be further developed, brimstone and "other" sources account for 8% and 13% respectively but these percentages are expected to rise as new deposits of sulphur ore, natural gas and oil are utilised. This trend seems particularly true in the new industrial areas. There are reports of a chain of sulphuric acid plants to be constructed in the southern Ukraine and Black Sea areas which may use as much as one-half million tons brimstone.

It has been claimed by Mr. Krushchev that the Soviet Union has the world's largest deposits of natural sulphur, and although this statement is vague it does imply that officially no supply problem for new industries is expected.

New deposits of sulphur include the Drogobych area in the Ukraine where extraction of sulphur has already started. This is one of the many recently discovered Ukrainian deposits up to 33 feet thick and amenable to open cast mining. They evidently are part of the formation which extends eastwards from the Vistula. A large sulphur processing plant is being built and will, reports state, have a scheduled output of 100,000 tons a year. Natural gas is being treated in a nearby area but details of sulphur recovery are not available. Gypsum deposits in Lithuania are also considered as a possible source of sulphur for the fertilizer industry. Sulphur deposits in the Kurile Islands have been mentioned and a further deposit of sulphur has been discovered in the Kamchatka Peninsula, whilst in the Udorski district of the Komi Republic the possibility of building a sulphuric acid plant in proximity to sulphur deposits has been studied.

No figures have been given for sour natural gas resources but they are very considerable and it is interesting to note that the recently published list of plant requirements to be obtained from abroad include a plant for the recovery of H_2S from natural gas. This would appear to be an indication that although at present little has been done in the way of sulphur recovery from natural gas a determined effort is to be launched.

Resources of natural gas and oil are to be further developed in the recovery of sulphur. Refineries at Kuibyshev, a major chemical centre, will recover sulphur from crude oil and it is probable that plants at Odessa will also use the same process.

Statistical Appendix

United States

		PRODUCTION		STOCKS		EXPORTS	IMPORTS
		Frasch	Recovered	Frasch	Recovered		
1953		5,155,342	337,099	3,022,486	107,344	1,241,536	
1954		5,515,543	357,400	3,228,020	109,066	1,647,011	1,104
1955		5,738,978	398,780	3,181,198	120,267	1,595,419	38,317
1956		6,423,883	464,758	3,936,450	119,446	1,651,597	203,300
1957		5,491,210	519,078	4,422,548	157,075	1,651,093	484,680
1957	January	495,353	42,154	3,997,911	118,296	115,747	33,883
	February	439,997	39,000	4,087,925	116,713	74,698	29,141
	March	471,548	39,800	4,102,394	111,905	99,637	44,673
	April	461,589	37,650	4,049,025	122,006	171,258	43,897
	May	429,227	42,400	4,092,772	127,908	113,147	39,847
	June	439,513	44,867	4,086,614	144,753	172,977	24,638
	July	459,534	45,311	4,153,206	150,518	118,814	47,918
	August	469,987	46,705	4,173,199	153,478	161,337	42,053
	September	444,779	43,912	4,272,558	152,940	79,617	42,576
	October	462,145	47,299	4,304,891	154,566	163,430	32,076
	November	445,908	41,882	4,354,962	154,285	138,852	31,944
	December	471,630	48,098	4,422,548	157,075	152,788	77,047
1958	January	461,285	53,673	4,540,198	161,348	87,430	36,221
	February	415,186	49,174	4,620,606	163,793	103,376	49,583
	March	429,475	51,104	4,620,947	163,462	127,713	

Official Bureau of Mines Data (long tons of 2,240lbs.)

SULPHUR EXPORTS

Long Tons

	1st Qtr. 1958	1st Qtr. 1957		1st Qtr. 1958	1st Qtr. 1957
Canada	30,913	17,002	Algeria	4,860	4,000
Guatemala	50	—	Morocco	—	4,000
Cuba	—	6,243	Un. of S. Africa	16,500	30,350
Costa Rica	22	—	Venezuela	396	544
N. Antilles	2,500	—	Pakistan	295	98
Brazil	21,134	24,264	Indonesia	1,000	—
United Kingdom	54,485	65,999	Korean Repub.	229	—
Belgium	23,350	13,550	N. Zealand	12,204	7,805
France	37,790	34,200	Uruguay	1,741	1,370
W. Germany	12,320	11,050	Argentina	984	7,901
Austria	10,000	4,000	Netherlands	5,250	—
Iran	3,000	2,972	Switzerland	1,700	—
India	31,750	32,620	Poland	2,500	—
Philippines	47	580	Lebanon	1,500	—
Australia	41,999	12,475	Other countries	—	9,157
			Total	318,519	290,082

West Germany

PYRITES IMPORTS

Metric Tons

	1957	Jan.-Feb. 1958
Finland	47,392	1,566
Greece	4,318	1,104
Italy	550	—
Jugoslavia	27,827	—
Norway	179,166	19,928
Portugal	43,346	8,476
Sweden	10,122	—
Spain	607,728	74,873
Turkey	38,634	5,851
Canada	79,716	2,648
Cuba	78,188	10,901
Cyprus	385,033	40,283
Total	1,502,020	165,630

CRUDE SULPHUR IMPORTS

Metric Tons

	1957	Jan.-Feb. 1958
Italy	1,000	—
U.S.A.	52,122	5,805
Mexico	11,029	3,472
Chile	359	—
Total	64,510	9,277

REFINED SULPHUR IMPORTS

Metric Tons

	1957	Jan.-Feb. 1958
Great Britain	17	
Italy	139	
U.S.A.	197	20
		—
Total	353	20
		—

Italy

FUSED SULPHUR PRODUCTION

Metric Tons

	1956	*1957*
Sicily	146,173	143,643
Mainland	28,150	33,404
Total	174,323	177,047

*SULPHUR STOCKS**

	1956	*1957*	*1958*
Sicily	329,472	275,851	195,419
Mainland	6,444	3,710	9,405
Total	335,916	279,561	204,824

*As at 1st January.

DOMESTIC SULPHUR CONSUMPTION

Metric Tons

	1956	*1957*
Refined and Ground	50,209	60,185
Carbon bisulphide	41,962	40,458
Cellulose	13,037	11,046
Polysulphides	2,476	2,872
Other Users	3,176	4,188
Total	110,860	118,749

FUSED SULPHUR EXPORTS

Metric Tons

	1956	*1957*
Austria	3,272	3,825
Czechoslavakia	3,602	4,500
France	49,695	38,487
Greece	1,250	1,200
Germany	—	1,000
Yugoslavia	—	7,024
Norway	1,800	—
Poland	500	2,500
Portugal	3,250	—
U.S.S.R.	7,019	19,156
Rumania	—	1,848
Sweden	12,130	1,000
Hungary	832	—
Algeria	2,310	1,410
Egypt	1,042	8,432
Tunisia	14,490	19,720
Israel	19,775	22,245
Iran	—	900
Lebanon	—	660
Pakistan	—	7
Total	120,967	134,004

Netherlands

PYRITES IMPORTS

Metric Tons

	1957	*Jan.-April 1958*
Portugal	76,504	21,877
Sweden	4,728	—
Spain	153,962	8,195
Cyprus	111,524	32,013
Norway	5,026	3,589
Greece	14,602	—
Ireland	320	—
Italy	—	28,426
Others	5	—
Total	366,671	94,100

SULPHUR IMPORTS

Metric Tons

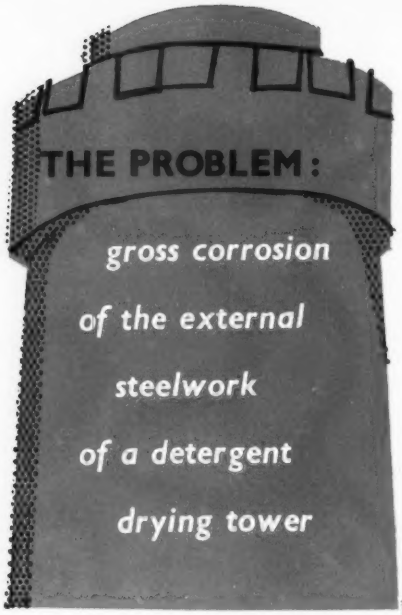
	1957	*Jan.-April 1958*
W. Germany	1,136	3,860
Mexico	22,573	10,677
Belgium	267	43
Great Britain	26	12
Others	69	273
Total	24,071	14,865

Mexico

SULPHUR PRODUCTION

Long Tons

	Pan American Sulphur Co.	*Gulf Sulphur Corporation*	*PEMEX and Texas Gulf Sulphur*	*Negociacion Minera de Azufre SA*	*Total*
1957 October	72,455	21,353	15,500	1,500	110,900
November	66,905	19,783	12,500	1,000	100,188
December	69,559	18,718	15,000	1,505	104,777
1958 January	70,627	18,940	22,800	1,200	113,567
February	64,182	14,056	13,000	1,500	92,738
March	73,743	21,945	10,721	1,500	107,909
April	70,235	20,800	11,500	1,500	104,035
May	78,221	18,983	11,777	1,575	110,556



High humidity, high temperature and chemical vapours are part and parcel of the detergent drying process at the works of Joseph Crosfield Ltd., Warrington. The detergent slurry is dried in a tower at 100°C. and when the moisture has been freed from dust, it is exhausted at the top of the tower, via a wet scrubbing system. This process quickly eats into the external steelwork and conventional paints have given only short-lived protection.

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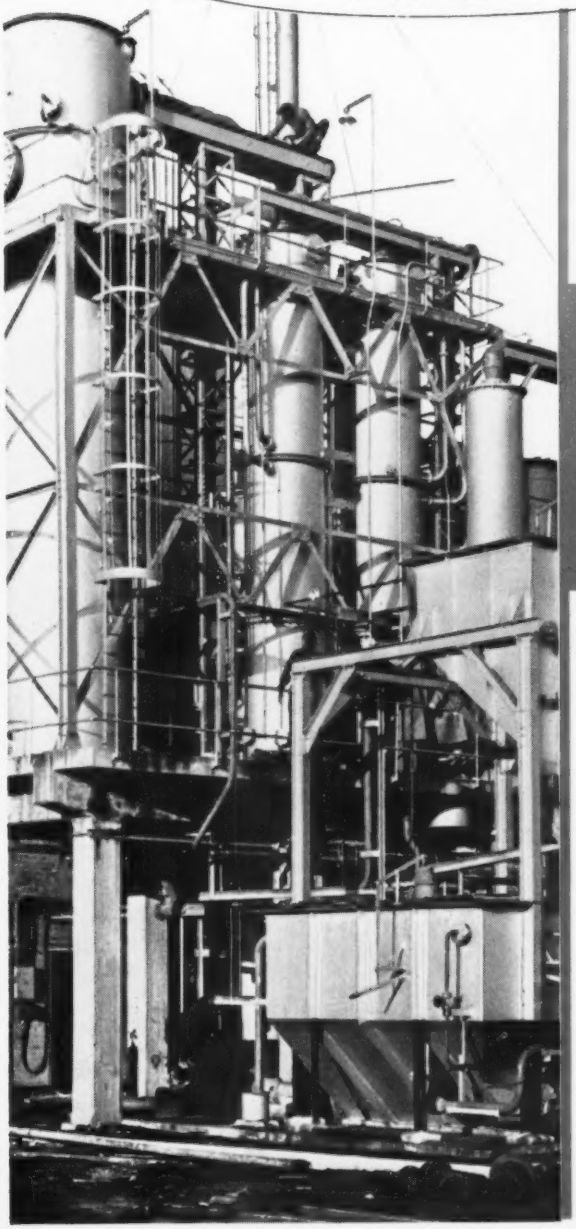

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